NASW-3681

(NASA-CR-173999) SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. CONTRACTOR ORIENTATION BRIEFINGS Final Report (TRW, Inc., Cleveland, Ohio.) 602 p HC A99/MF A01 CSCL 22B G3/15

N84-34460

Unclas 23248

SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS

CONTRACTOR ORIENTATION BRIEFINGS

SEPTEMBER 14-15, 1982

NASA
National Aeronautics and Space Administration

SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS
CONTRACTOR ORIENTATION BRIEFING

PROCEEDINGS

TABLE OF CONTENTS

INTRODUCTION AND STUDY MANAGEMENT

E. BRIAN PRITCHARD

SPACE STATION TASK FORCE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE STATION MISSION ANALYSIS ACTIVITIES

Sponsor in-house and contractor studies to

- o reach out to user communities
  - science
  - applications
  - commercial
  - technology development
  - national security
  - operations
- o involve users early on
- o define time-phased user mission requirements
- o derive space station architecture from mission requirements

Exchange mission analysis data with potential international partners

- o ESA, Japan, Canada, Germany, France and Italy

Use Mission Requirements Working Group to:

- o integrate results
- o establish mission models
- o prepare mission description document

3026B/2

MISSION ANALYSIS STUDIES

- eight $787,500 studies to analyze the science, applications, technology development, national security and space operations missions that require or would materially benefit from a permanent space station in low earth orbit
- contractors: Boeing, General Dynamics, Grumman, Lockheed, McDonnell Douglas, Martin Marietta, Rockwell, and TRW
- emphasis on user communities. Architecture, not configuration
- schedule

RFP release	June 28, 1982
Contracts signed	August 20, 1982
Mid-term Briefings	November 15-18, 1982
Final Briefings	February 21-March 4, 1983
Final Reports	April 22, 1983

- participation by DOD
- similar studies by ESA, Japan, Canada, Germany and France
- studies will be integrated by NASA into single set of time-phased mission objectives and corresponding space station requirements, from which architectural options will be derived

SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS
TECHNICAL DIRECTION

- ALL TECHNICAL DIRECTION WILL COME FROM THE STUDY MANAGER, BRIAN PRITCHARD
- PRIMARY TECHNICAL DIRECTION FROM THIS POINT WILL COME AFTER THE MID TERM BRIEFINGS-- NOVEMBER 29 - DECEMBER 2
- EACH CONTRACTOR IS TO USE HIS OWN INGENUITY AND CREATIVITY WITH A MINIMUM OF TECHNICAL DIRECTION FROM NASA
- THE NASA STUDY MANAGER WILL HOLD BIWEEKLY TELECONS WITH EACH CONTRACTOR STUDY MANAGER TO <u>BRIEFLY</u> REVIEW STATUS AND PROBLEMS
- A TECHNICAL POINT OF CONTACT HAS BEEN ESTABLISHED AT EACH CENTER TO PROVIDE INFORMATION AS REQUIRED BY THE CONTRACTORS
- FOLLOWING THE FINAL BRIEFINGS A WRAP-UP SESSION WILL BE HELD WITH EACH CONTRACTOR TO REVIEW FINAL REPORT PLANS

CENTER POINTS OF CONTACT

CENTER	CONTACT	TELEPHONE NUMBER
ARC	JOE SHARP	(415) 965-5100
GSFC	STEVE HOLT	(301) 344-7579
JPL	JIM DUNNE	(213) 354-6904
JSC	BARRY WOLFER	(713) 483-4227
KSC	DAVE MOJA	(305) 867-3644
LARC	CHUCK ELDRED	(804) 827-3911
LERC	SOL GORLAND	(216) 433-5159
MSFC	PETE PRIEST	(205) 453-0413

CENTER________________________

MAS STUDY CONTRACTOR CONTACT LOG

#	DATE	CONTRACTOR	CONTACT

MAS STUDY CONTRACTOR CONTACT FORM

CONTACT #________________

DATE________________

CONTRACTOR:	CENTER:
CONTACT:	CONTACT:
JOB DESC:	ORGN:

INQUIRY:

RESPONSE:

MATERIAL PROVIDED OR RECOMMENDED:

COMMENTS:

AUTOMATED MISSION AND MISSION MODEL DATA BASE

DESCRIPTION

- INTERACTIVE DATABASE SYSTEM ON LARC MINICOMPUTER
- MISSION DATA INDEPENDENT OF MISSION MODELS
- MISSION MODELS BUILT FROM MISSION DATA BASE
- GRAPHICAL ANALYSIS OF MISSION MODELS

IMPLEMENTATIONS

- USERS' GUIDE, USER WORKSHOP
- INTERACTIVE REMOTE INPUT AND ANALYSIS

ISSUES

- FINALIZE MISSION DATA FORMS
- USE STANDARD TERMINALS (TEKTRONIX 4010 SERIES)
- DATA ACCESS CONTROL, VIEWING PROTOCOL
- STANDARD MISSION MODEL ANALYSIS NEEDS

MISSION NAME

CODE

CONTACT (Name address, phone)

STATUS

☐ Operational

☐ Approved

☐ Planned

☐ Candidate

☐ Opportunity

Year of first flight ____________

Number of missions ____________

OBJECTIVE

TYPE

Science and Applications

☐ Astrophysics
☐ Communications
☐ Earth and Planetary Exp.
☐ Environmental Observations
☐ Life Sciences
☐ Materials Processing

Commercial

☐ Earth and Ocean Operations
☐ Communications
☐ Materials Processing
☐ Industrial Research

National Security

☐ Research and Development
☐ Operational

Technology Development

☐ Generic
☐ Flight Missions
☐ Operations
☐ Basic Physics and Chemistry

DESCRIPTION

ORBIT CHARACTERISTICS

Apogee, km ______ Perigee ______ Tolerance ± ______

Inclination, deg ______ Tolerance ± ______

Argument of perigee, deg ______ Ephemeris accuracy ______

Synchronization ☐ None ☐ Earth ☐ Sun ☐ Other ______

POINTING(Real Time)

View direction ☐ Inertial ☐ Solar ☐ Earth ☐ Other ______

Pointing accuracy ______ Field of view ______

Specific targets Stability angle ______

DATA/COMMUNICATIONS

Monitoring requirements ☐ None ☐ Realtime ☐ Offline ☐ Other

Data rate ______ Frequency, Hz ______ Bandwidth, Hz ______

☐ Onboard data processing Data storage, kB ______

☐ Encryption/Decryption required

POWER

	Power, W	Duration, hr
Operating	______	______
Standby	______	______
Peak	______	______

Voltage, V ______ Frequency, Hz ______

Duty Cycle Description

ORBIT TRANSFER STAGE (IF KNOWN)

☐ PAM-A ☐ PAM-D ☐ IUS

THERMAL

Type of concept ____

Temperature, deg C Operational min ____ max ____ Peak ____

Cryogenic Load ____ Temperature ____ Duration ____

Heat Rejection, W Operational ____ Peak ____

CREW REQUIREMENTS

Estimated crew size Permanent ____ Service ____ EVA ☐ Yes ☐ No

Manhours/mission ____ Average time between visits, days ____

Skills required ____

PHYSICAL CHARACTERISTICS

Launch mass, kg ____ Deployed mass ____ Expendables ____

Length, m Launch w/OTV ____ Undeployed ____ Deployed ____

Diameter, m Launch ____ Undeployed ____ Deployed ____

Center of gravity location, m X ____ Y ____ Z ____

SPECIAL CONSIDERATIONS/CLARIFICATIONS	SKETCH

MID-TERM BRIEFINGS

PRIMARY THRUST -- MISSION REQUIREMENTS

- APPROACH
- USER MISSIONS/VALIDATION CRITERIA
- MISSION REQUIREMENTS
- RATIONALE FOR TIME PHASING
- PRELIMINARY MISSION MODELS

SECONDARY THRUST -- APPROACH AND PRELIMINARY RESULTS ON ARCHITECTURE AND COST/BENEFITS ANALYSES

FORMAT -- 1/2 DAY BRIEFING INDIVIDUALLY BY EACH CONTRACTOR
AUDIO HOOKUPS WITH AT LEAST JSC AND MSFC (EXTRA COPIES OF VIEWGRAPH MATERIAL AT THE CENTERS)

DOD STUDY MANAGEMENT

MAJOR RICK ZWIRNBAUM

SPACE DIVISION

UNITED STATES AIR FORCE

DOD GUIDANCE

- DOD POINT OF CONTACT IS AIR FORCE SYSTEM COMMAND'S SPACE DIVISION

- DOD WILL PROVIDE NECESSARY GUIDANCE ON NATIONAL SECURITY: POLICY REQUIREMENTS, PLANS, SECURITY, ETC

  - ENCOURAGE CREATIVE, BROAD INVESTIGATION
  - NEED COMPREHENSIVE ASSESSMENT FOR EVALUATING POTENTIAL MILITARY APPLICATIONS OF SPACE STATION CONCEPTS

- IN GENERAL, CONTRACTOR QUERIES AND SPACE DIVISION RESPONSES WILL BE DOCUMENTED AND DISTRIBUTED TO ALL PRINCIPALS

  - INFORMATION SPECIFICALLY APPLICABLE TO CONTRACTOR PROPRIETARY EFFORTS WILL BE STRICTLY PROTECTED

SCIENCE AND APPLICATIONS REQUIREMENTS

FOR

SPACE STATION

ORIENTATION BRIEFING

SEPTEMBER 14, 1982

AGENDA

• INTRODUCTION	S. HOLT
• LIFE SCIENCES	W. BISHOP
• ASTROPHYSICS	G. NEWTON
• ENVIRONMENTAL SCIENCES	D. BUTLER
• EARTH & PLANETARY EXPLORATION	W. PIOTROWSKI
• MATERIALS PROCESSING	W. ORAN
• SPACELAB EVOLUTION	M. SANDER
• ADDITIONAL QUESTIONS & ANSWERS	FULL PANEL

SCHEDULE

- CURRENT PLANS & REQUIREMENTS (JUNE 1982)
  - NASA REVIEW
  - SPACE SCIENCE BOARD REVIEW
  - SPACE APPLICATIONS BOARD REVIEW
  - ADDITIONAL SCIENTIFIC INPUT
- ORIENTATION BRIEFING (SEPTEMBER 1982)
  - SPACE SCIENCE BOARD RECOMMENDATIONS
  - SPACE APPLICATIONS BOARD RECOMMENDATIONS
  - INTEGRATION OF ALL SCIENTIFIC INPUTS
  - NASA IDENTIFICATION OF "REQUIREMENTS"
- MID-TERM BRIEFING (NOVEMBER 1982)

SPACE SCIENCE BOARD

- JULY 27-28 REVIEW OF NASA SPACE STATION PLANS
- DETAILED SSB COMMITTEE STUDIES IN PROGRESS
- NOVEMBER 4-6 SSB MEETING TO REVIEW COMMITTEE STUDIES AND NASA PROGRESS
- FINAL REPORT AFTER CONCLUSION OF MISSION ANALYSIS CONTRACT PERIOD OF PERFORMANCE

SPACE APPLICATIONS BOARD SUMMER STUDY
ON THE
PRACTICAL APPLICATIONS OF SPACE SYSTEMS
AUGUST 15 - 21, 1982

- STATEMENT OF OBJECTIVE FROM THE SAB STUDY PLAN

  " ... DETERMINING GENERIC TECHNICAL REQUIREMENTS THAT SHOULD BE CONSIDERED IN CONCEPTUAL DESIGN OF SPACE STATIONS OR SPACE PLATFORMS, SO THAT ANY SUCH STATIONS OR PLATFORMS WOULD HAVE MAXIMUM UTILITY FOR PRACTICAL APPLICATIONS OF SPACE SYSTEMS."

- STUDY PANELS

  EARTH'S RESOURCES (A. RICHARD BALDWIN, CARGILL, INC.)

  EARTH'S ENVIRONMENT (LAWRENCE R. GREENWOOD, BALL CORPORATION)

  OCEAN OPERATIONS (JAMES H. GUILL, LOCKHEED MISSILES & SPACE CO.)

  SATELLITE COMMUNICATIONS (DONALD B. NOWAKOWSKI, WESTERN UNION)

  MATERIALS PROCESSING IN SPACE (ROBERT A. LAUDISE -- BELL
KENNETH A. JACKSON LABS)

  SYSTEMS DESIGN (ALBERT E. SABROFF, TRW)

SPACE APPLICATIONS BOARD SUMMER STUDY

REPORT SCHEDULE

- o ORAL REPORT TO ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS - AUGUST 21.

- o FOLLOWING NATIONAL RESEARCH COUNCIL REVIEW, TWO FORMAL REPORTS WILL BE MADE

  - A LETTER REPORT IN OCTOBER

  - A FINAL REPORT IN THE SPRING OF 1983

SPACE APPLICATIONS BOARD SUMMER STUDY

ORAL REPORT HIGHLIGHTS

- NO APPLICATIONS PANEL FOUND THEIR NEEDS ALONE SUFFICIENT TO JUSTIFY A SPACE STATION, BUT ALL STATED THAT A MANNED "SERVICE STATION" IN SPACE FOR SERVICING, REPAIR AND REPLACEMENT AND INSTRUMENT CALIBRATION WOULD REPRESENT AN IMPORTANT FUNCTIONAL CAPABILITY FOR FUTURE SYSTEMS

- THESE PANELS ARGUED THAT ADVANCES ARE NEEDED IN THE TECHNOLOGY OF APPLICATIONS SYSTEMS IN ORDER TO ACHIEVE A USEFULNESS WHICH JUSTIFIES THE DEVELOPMENT OF STATIONS OR PLATFORMS TO CARRY THEM

SPACE APPLICATIONS BOARD SUMMER STUDY

ORAL REPORT HIGHLIGHTS
(CONTINUED)

- EARTH OBSERVATION PANELS FOUND USEFUL APPLICATION FOR LARGE MAN-TENDED PLATFORMS IN NEAR POLAR ORBITS

  POTENTIAL NEEDS: BIG INSTRUMENTS - LIDAR AND MICROWAVE
  LONG TERM OBSERVATIONS
  INTEGRATED OBSERVATIONAL SYSTEMS

- THE SATELLITE COMMUNICATIONS PANEL FOUND THAT ALL OF ITS KNOWN REQUIREMENTS THROUGH THE YEAR 2000 COULD BE MET USING SHUTTLE/CENTAUR CAPABILITY. COST EFFECTIVENESS OF LEO STAGING TO GEO NEEDS STUDY, AND THE EMERGENCE OF MOBILE COMMUNICATIONS REQUIREMENTS COULD REQUIRE THE FABRICATION OF LARGE STRUCTURES IN LEO FOR TRANSFER TO GEO

- THE MATERIALS PROCESSING IN SPACE PANEL FOUND THAT MATERIALS SCIENCE, ALTHOUGH NOT A DRIVER, COULD BENEFIT FROM THE EXISTENCE OF A SPACE STATION IN ANY INCLINATION LEO

- THE SYSTEMS DESIGN PANEL STRONGLY RECOMMENDED EMPHASIS ON THE IMPROVEMENT OF THE CAPABILITIES AND ENABLING TECHNOLOGY OF MAN IN SPACE AND CAREFUL TRADE-OFFS BETWEEN TELEPRESENCE AND PHYSICAL PRESENCE. THE PANEL FOUND MAN-IN-SPACE AN APPLICATION IN ITS OWN RIGHT WITH SIGNIFICANT FUTURE POTENTIAL

SUMMARY

- NEW OPPORTUNITIES

  PERMANENT HABITABLE ENVIRONMENT

  CAPABILITY FOR SERVICING, CONSTRUCTION

  NODE FOR TRANSPORTATION, COMMUNICATION

- QUALIFICATIONS

  NOT NECESSARY FOR ALL REQUIREMENTS

  POSSIBLE CONTAMINATION/INCOMPATABILITIES

  COST/SCHEDULE IMPLICATIONS

- ORIENTATION BRIEFING IS A DESCRIPTION OF THE TOTAL NASA PROGRAM, WITH TENTATIVE BOUNDS ON THE REQUIREMENTS

- MID-TERM BRIEFING WILL IDENTIFY THAT PORTION OF THE PROGRAM WHICH APPEARS TO BE MOST SUITABLE FOR ASSOCIATION WITH THE SPACE STATION

- CONTRACTORS ARE ENCOURAGED TO BE IMAGINATIVE IN SATISFYING REQUIREMENTS FOR SCIENCE AND APPLI.ATIONS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

DATE: 9/14/82

LIFE SCIENCE CONSIDERATIONS FOR

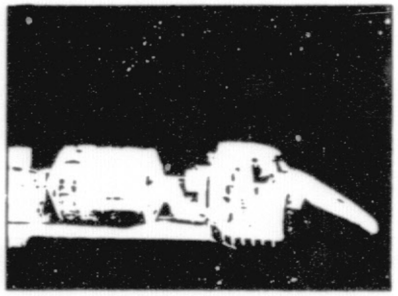
SPACE STATION

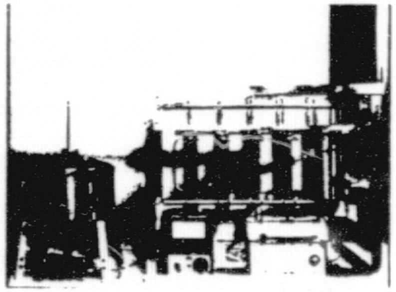
W. P. BISHOP

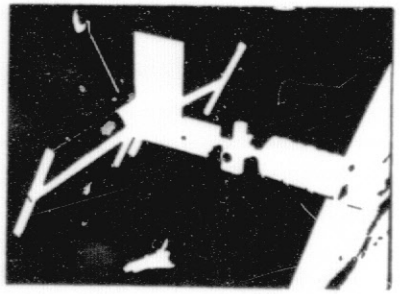
14 SEPTEMBER 1982

LIFE SCIENCES PROGRAM

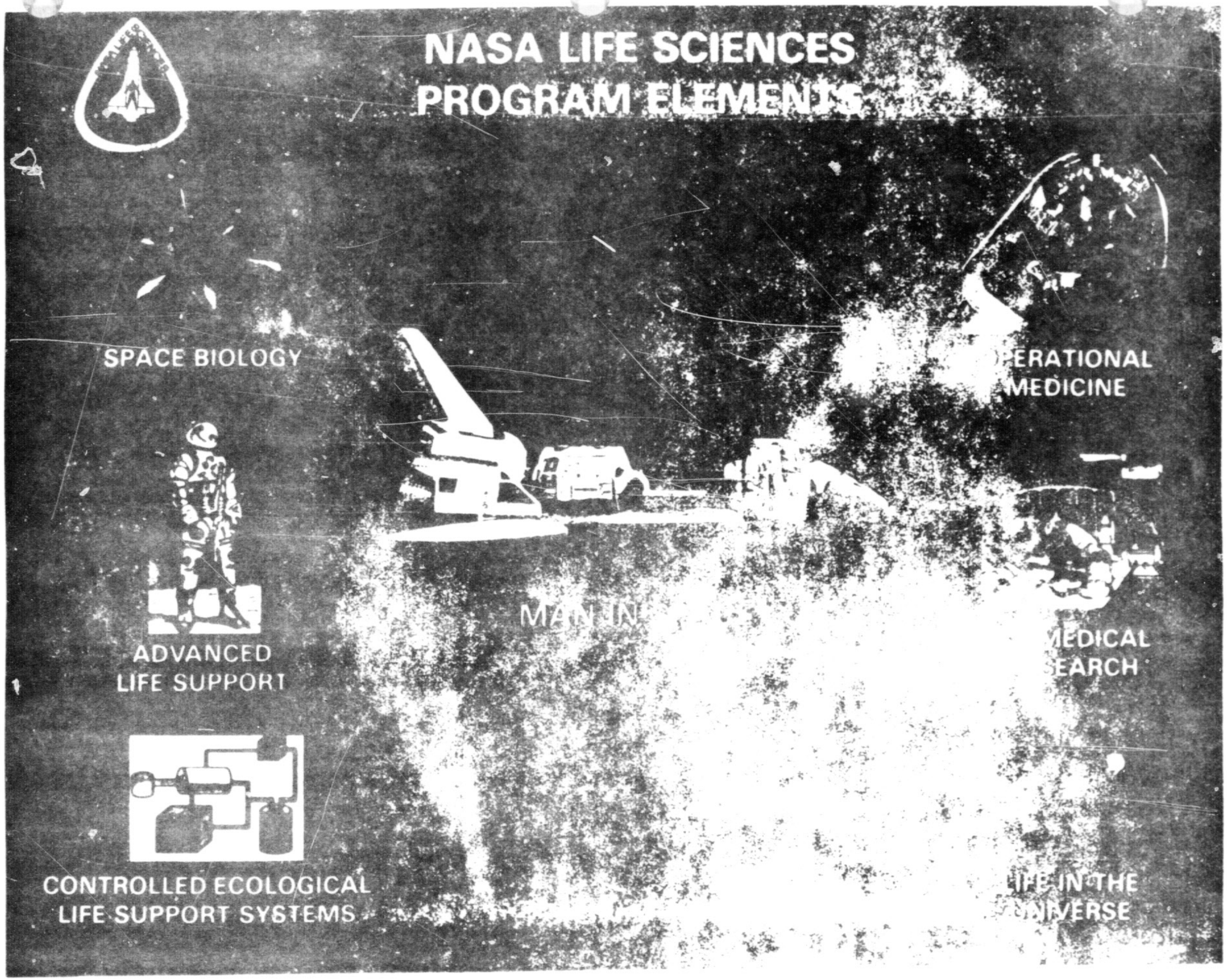
LIFE SCIENCE GOALS







- MAXIMIZE HUMAN PRODUCTIVITY IN SPACE
  - UNDERSTAND PHYSIOLOGY
  - EXTEND PERFORMANCE
  - HEALTH MAINTENANCE
  - DEVELOP COUNTERMEASURES
- PROVIDE SCIENTIFIC BASE FOR FUTURE MANNED MISSIONS
  - LONG-TERM PHYSIOLOGICAL CHANGES
  - ADVANCED LIFE SUPPORT
  - MEDICAL CARE IN SPACE
- USE SPACE ENVIRONMENT TO UNDERSTAND BIOLOGICAL SYSTEMS
- UNDERSTAND THE ORIGIN, ROLE AND DISTRIBUTION OF LIFE IN THE UNIVERSE

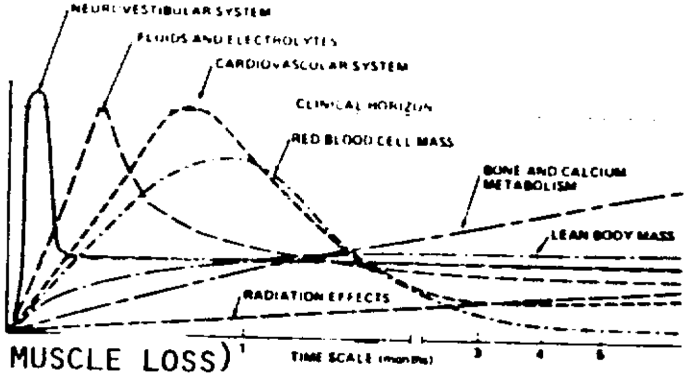

NASA LIFE SCIENCES
PROGRAM ELEMENTS
SPACE BIOLOGY
ADVANCED
LIFE SUPPORT
CONTROLLED ECOLOGICAL
LIFE SUPPORT SYSTEMS
MAN IN
ERATIONAL
MEDICINE
MEDICAL
EARCH
LIFE IN THE
NIVERSE

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

DATE

LIFE SCIENCES PROGRAM

- UNDERSTAND AND CONTROL THE EFFECTS OF THE SPACE ENVIRONMENT ON MEDICAL & BIOLOGICAL PROCESSES



OPERATIONAL MEDICINE
- DATA FROM STS FLIGHTS
- EFFICACY OF COUNTERMEASURES

BIOMEDICAL RESEARCH
- SPACE MOTION SICKNESS
- CARDIOVASCULAR DECONDITIONING
- FLUID/ELECTROLYTE CHANGES
- CALCIUM LOSS FROM BONE
- OTHERS (RADIATION, RED BLOOD CELLS, MUSCLE LOSS)

LIFE SUPPORT SYSTEMS
- OPEN-LOOP WATER/OXYGEN SYSTEMS
- CLOSED-LOOP WATER/OXYGEN/NUTRIENT SYSTEMS

SPACE BIOLOGY
- EFFECTS OF GRAVITY ON PLANT SYSTEMS
- ROLE OF GRAVITY IN BASIC BIOLOGICAL PROCESSES

EXOBIOLOGY
- PREBIOLOGICAL PROCESSES/EXTRATERRESTRIAL LIFE
- GLOBAL BIOLOGY

FLIGHT PROGRAM
- SPACELAB AND STS EXPERIMENTS

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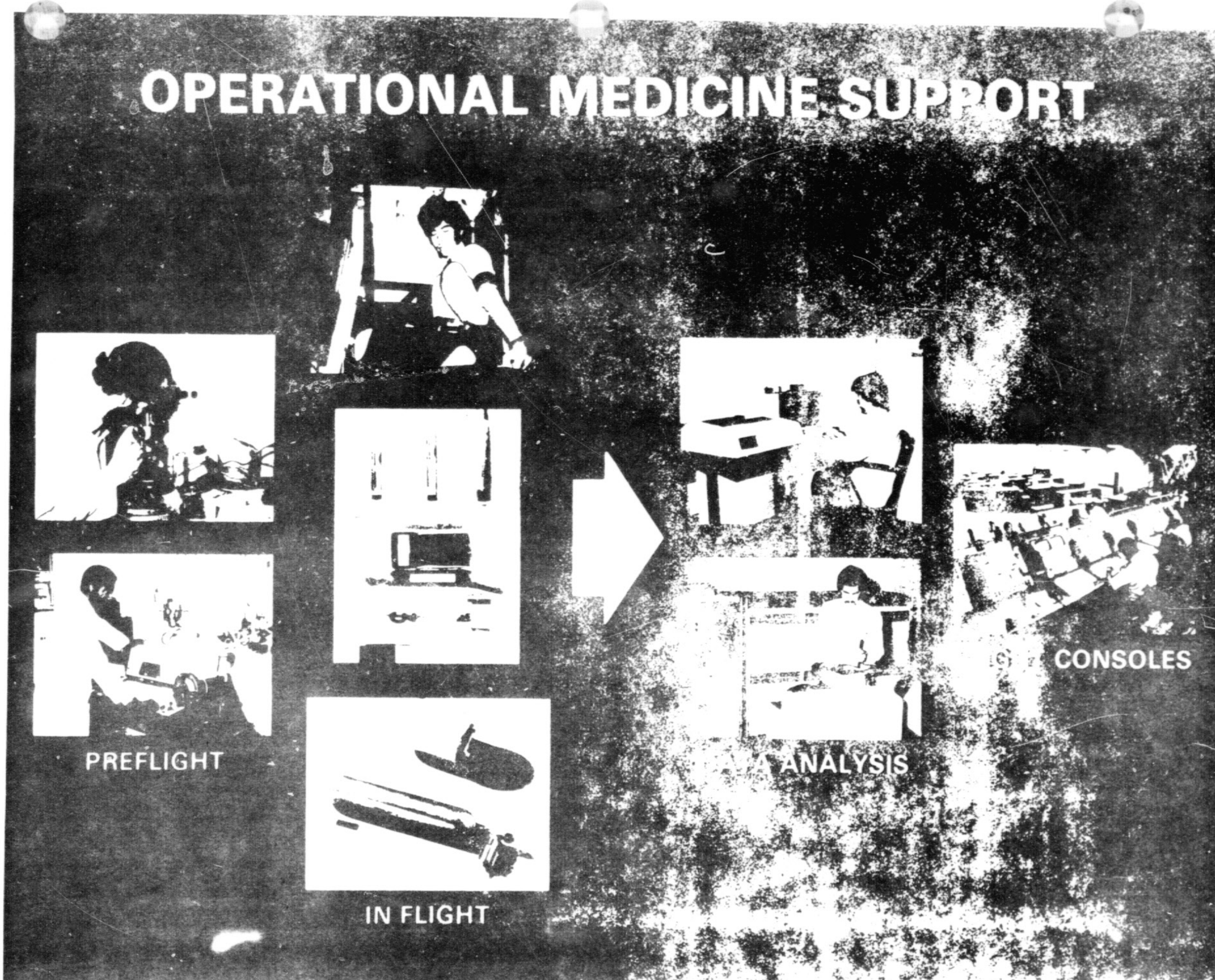
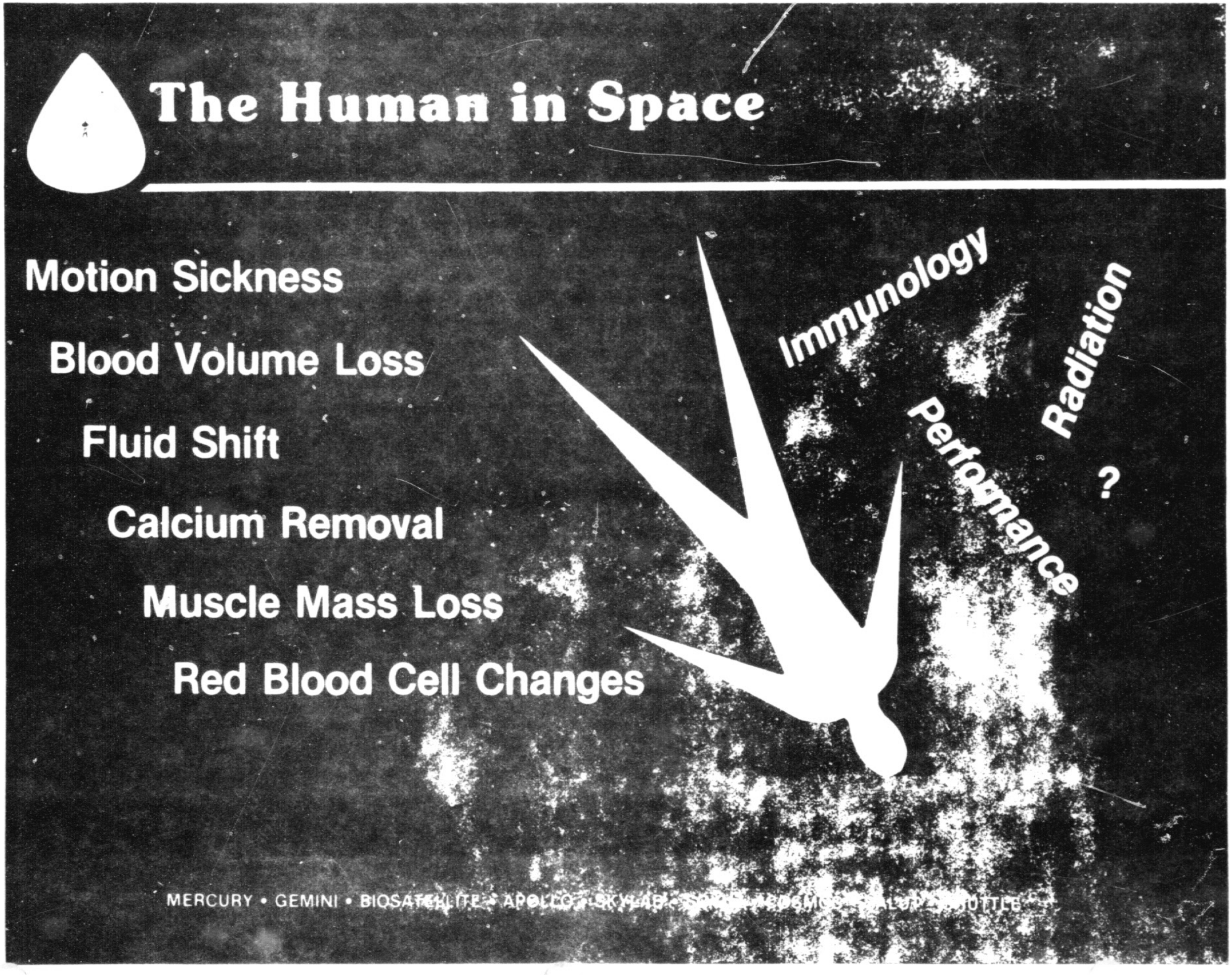

OPERATIONAL MEDICINE SUPPORT
PREFLIGHT
IN FLIGHT
ANALYSIS
CONSOLES


The Human in Space
Motion Sickness
Blood Volume Loss
Fluid Shift
Calcium Removal
Muscle Mass Loss
Red Blood Cell Changes
Immunology
Radiation
Performance
?
MERCURY • GEMINI • BIOSATELLITE • APOLLO • SKYLAB

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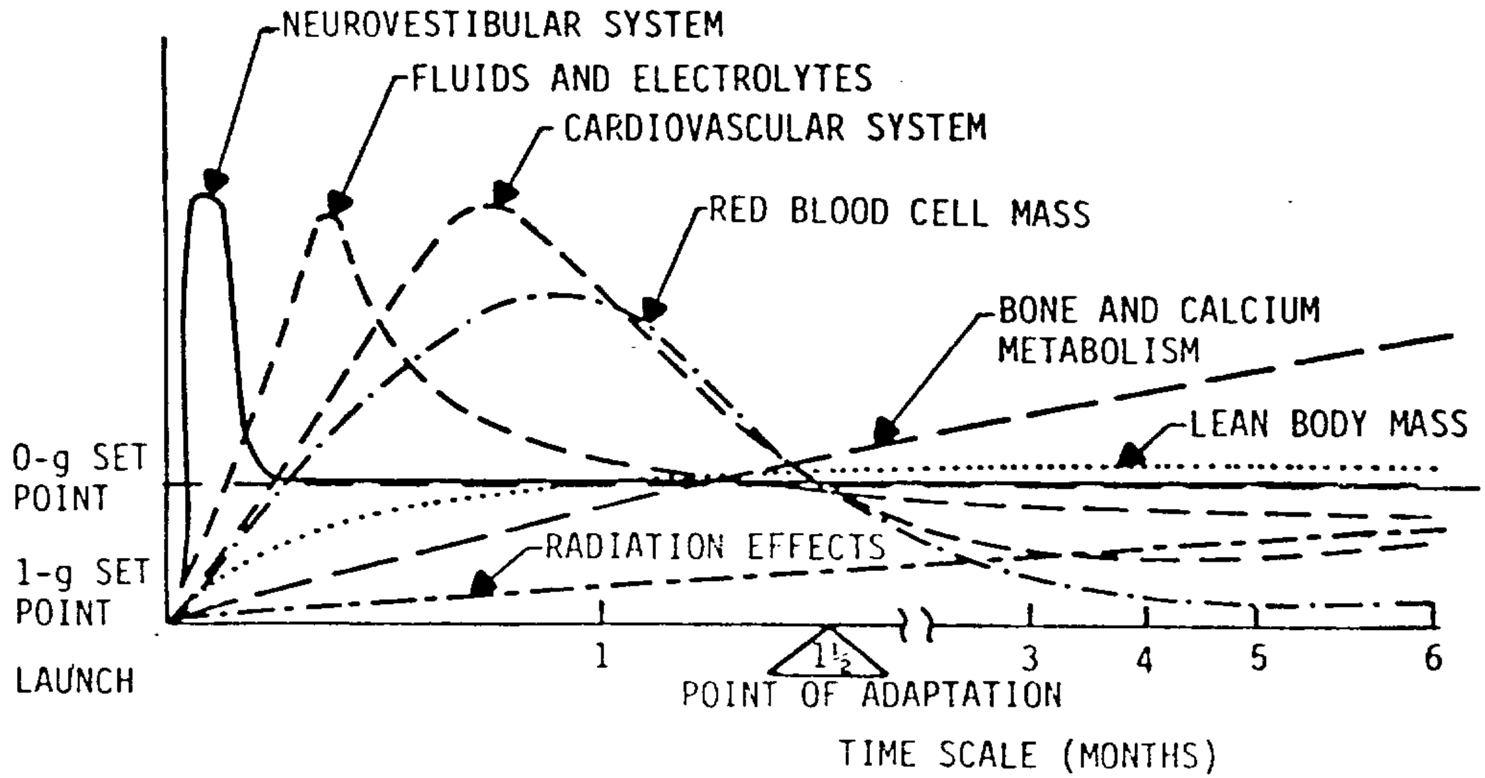
LIFE SCIENCES

DATE: 9/14/82

INFLIGHT



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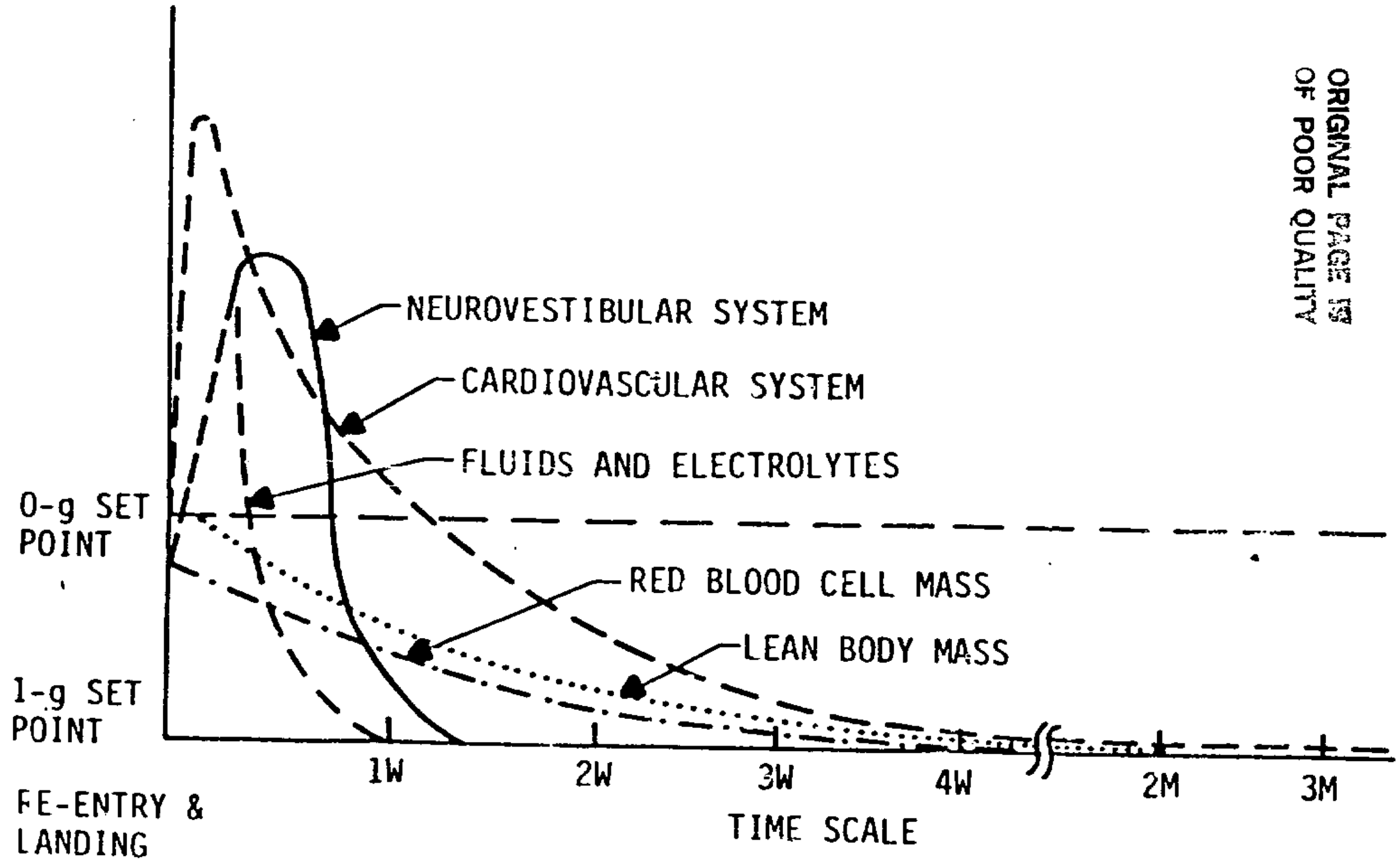
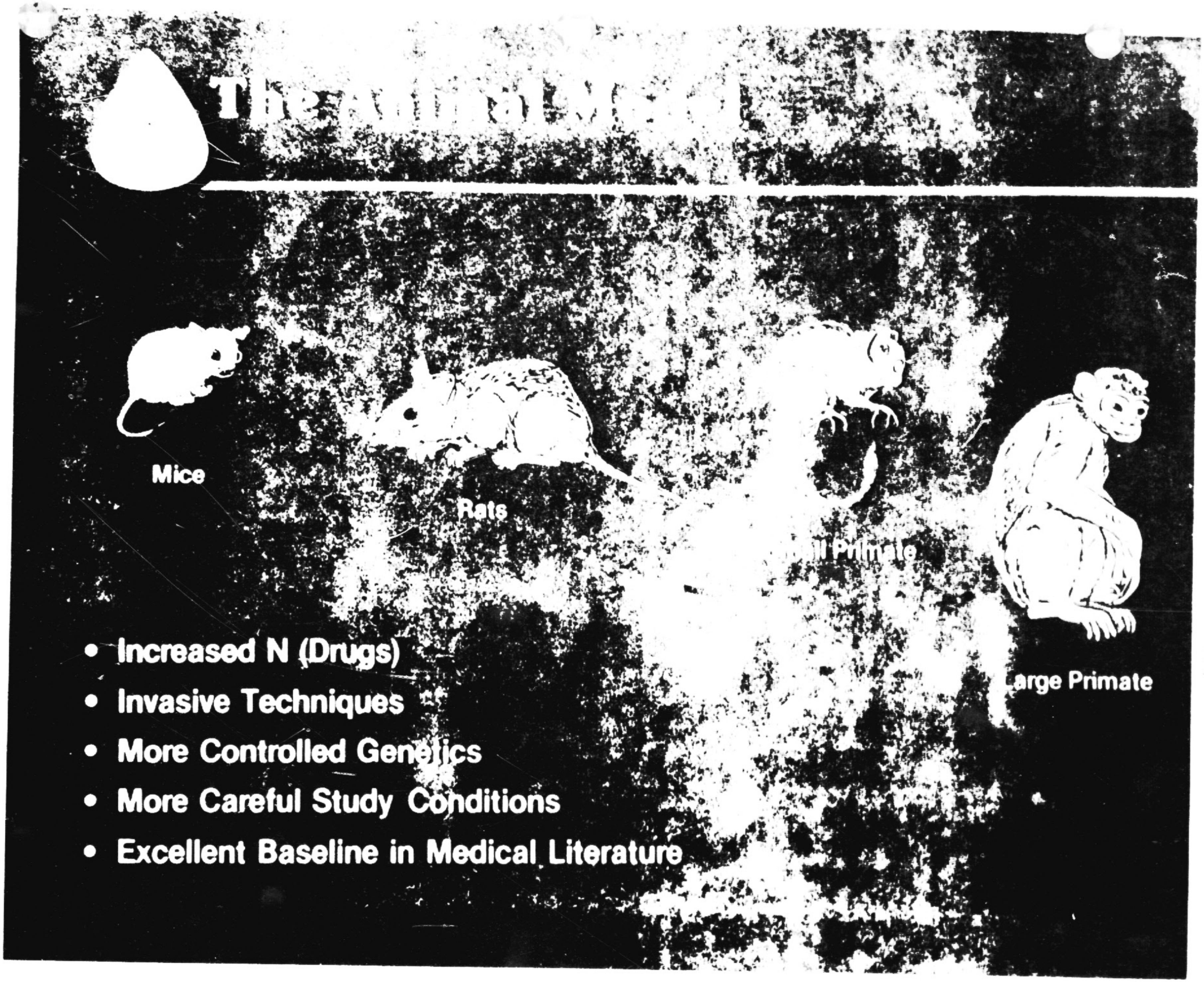
LIFE SCIENCES

DATE: 9/14/82

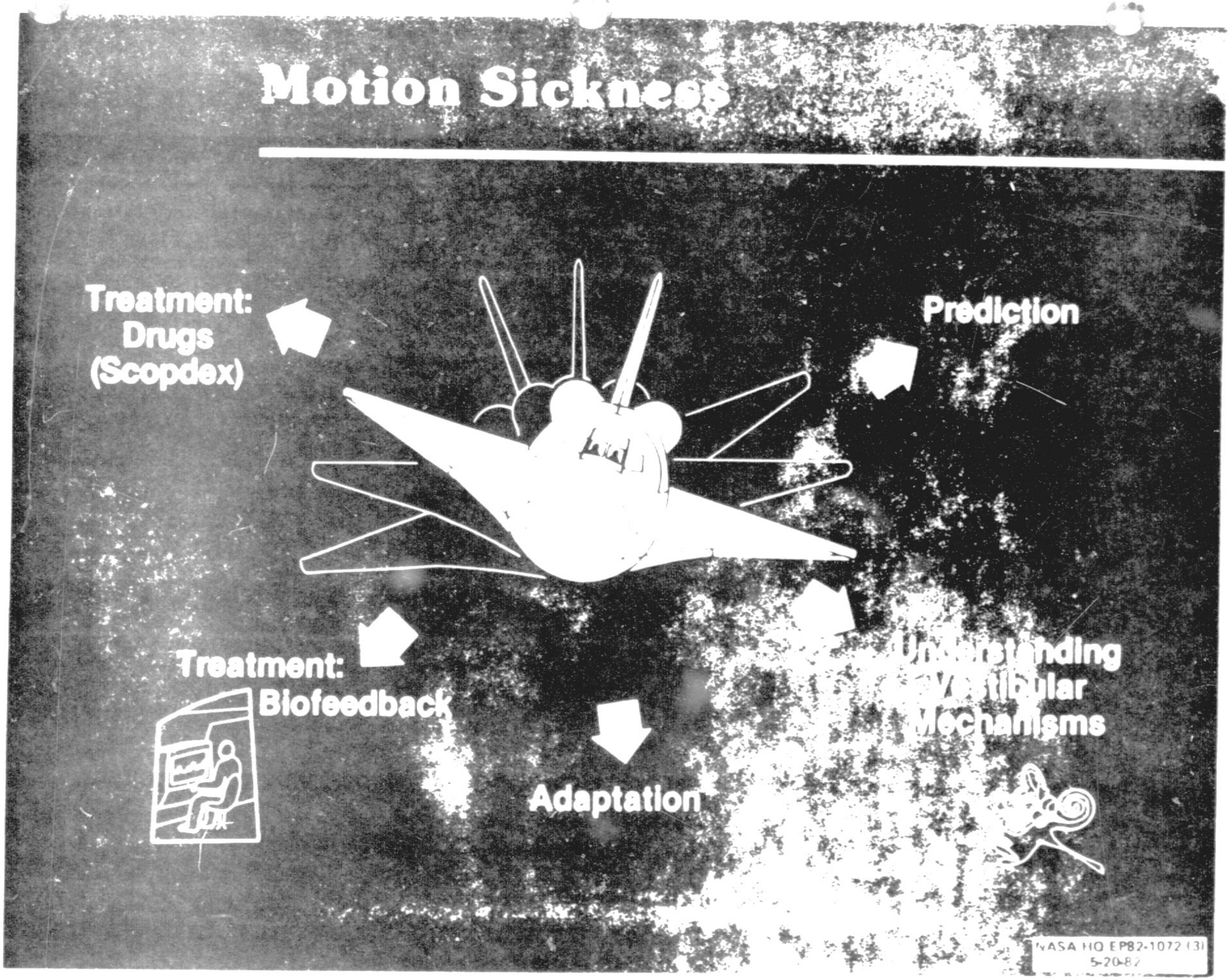
POSTLANDING

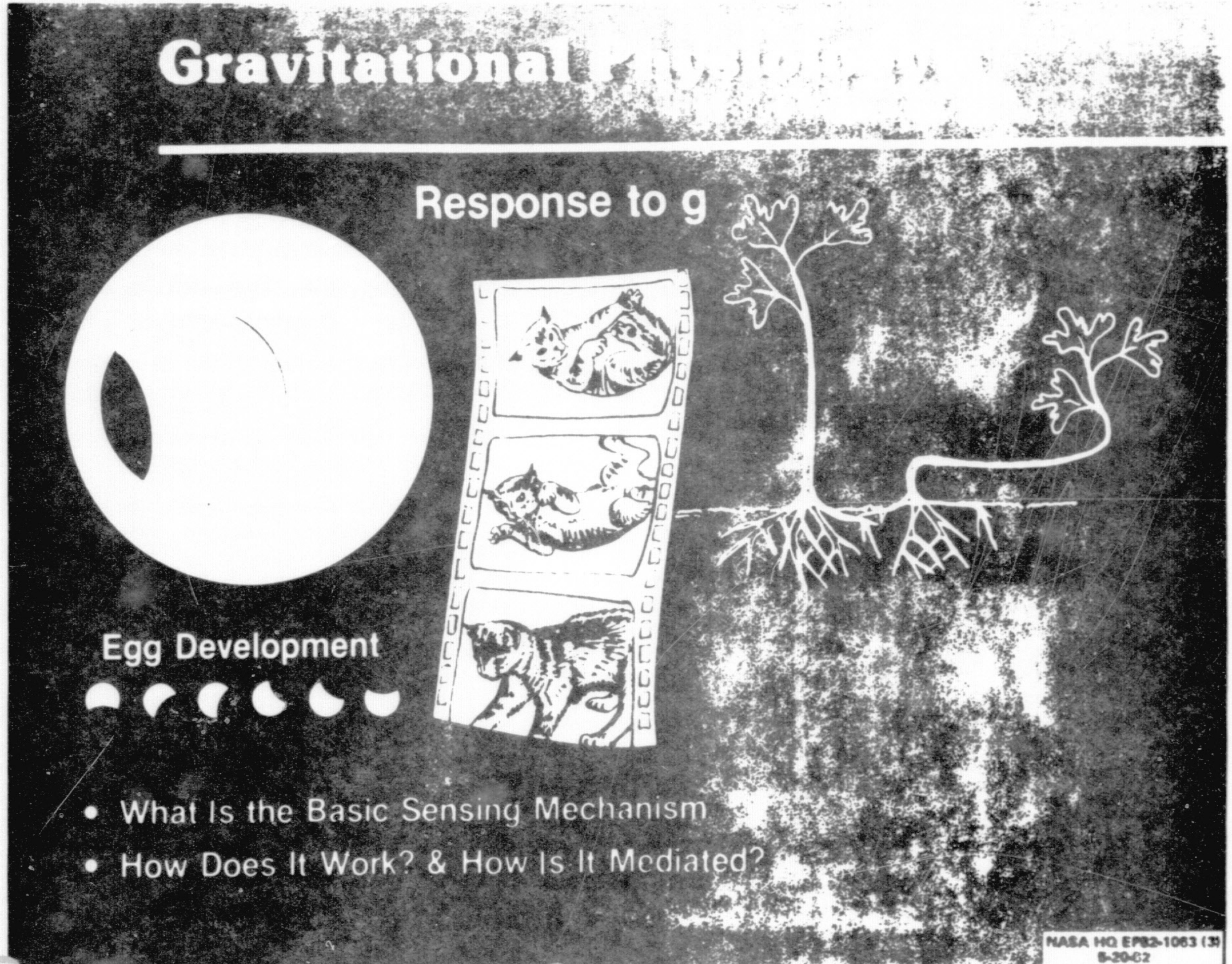


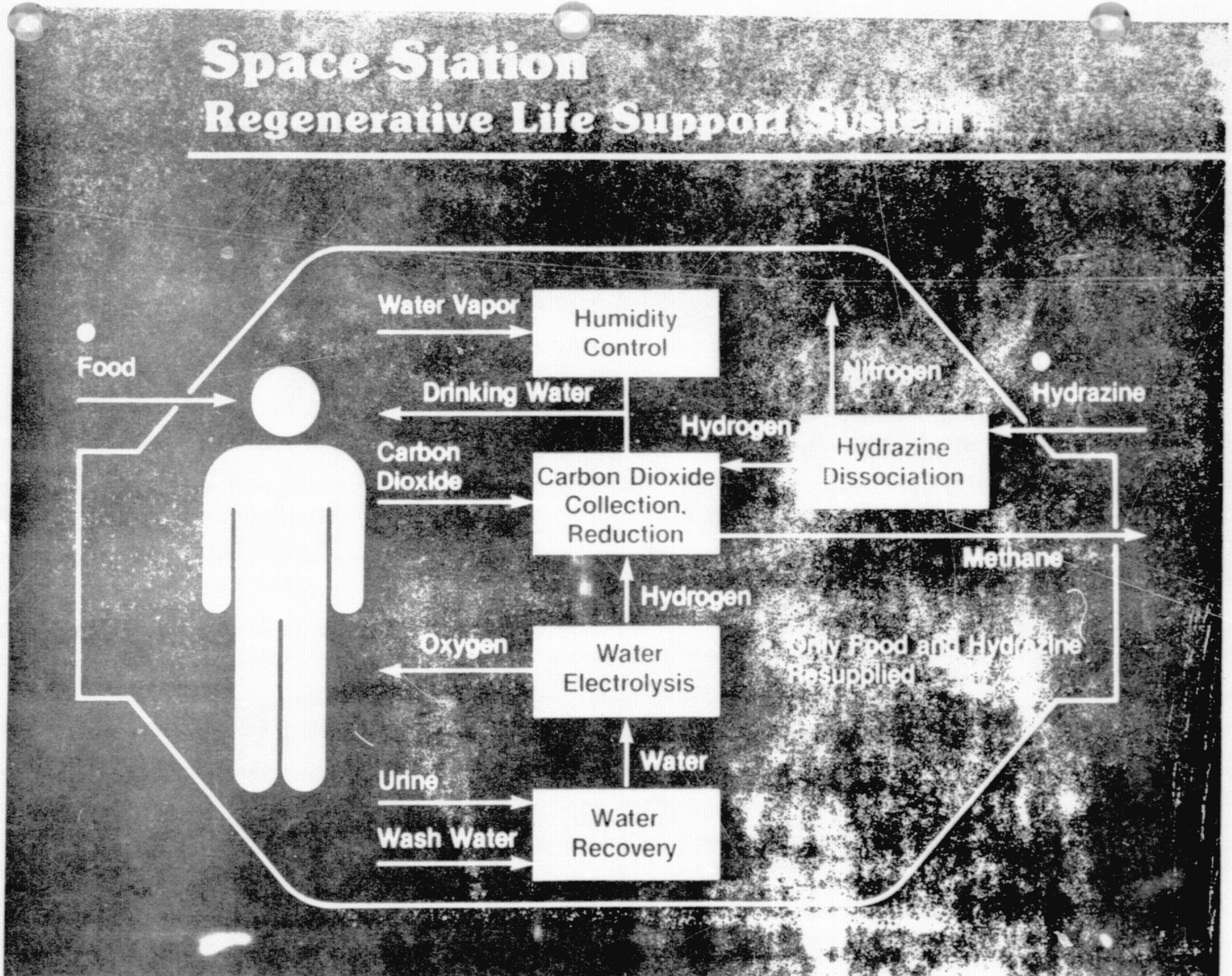

The
Mice
Rats
Primate
arge Primate
• Increased N (Drugs)
• Invasive Techniques
• More Controlled Genetics
• More Careful Study Conditions
• Excellent Baseline in Medical Literature

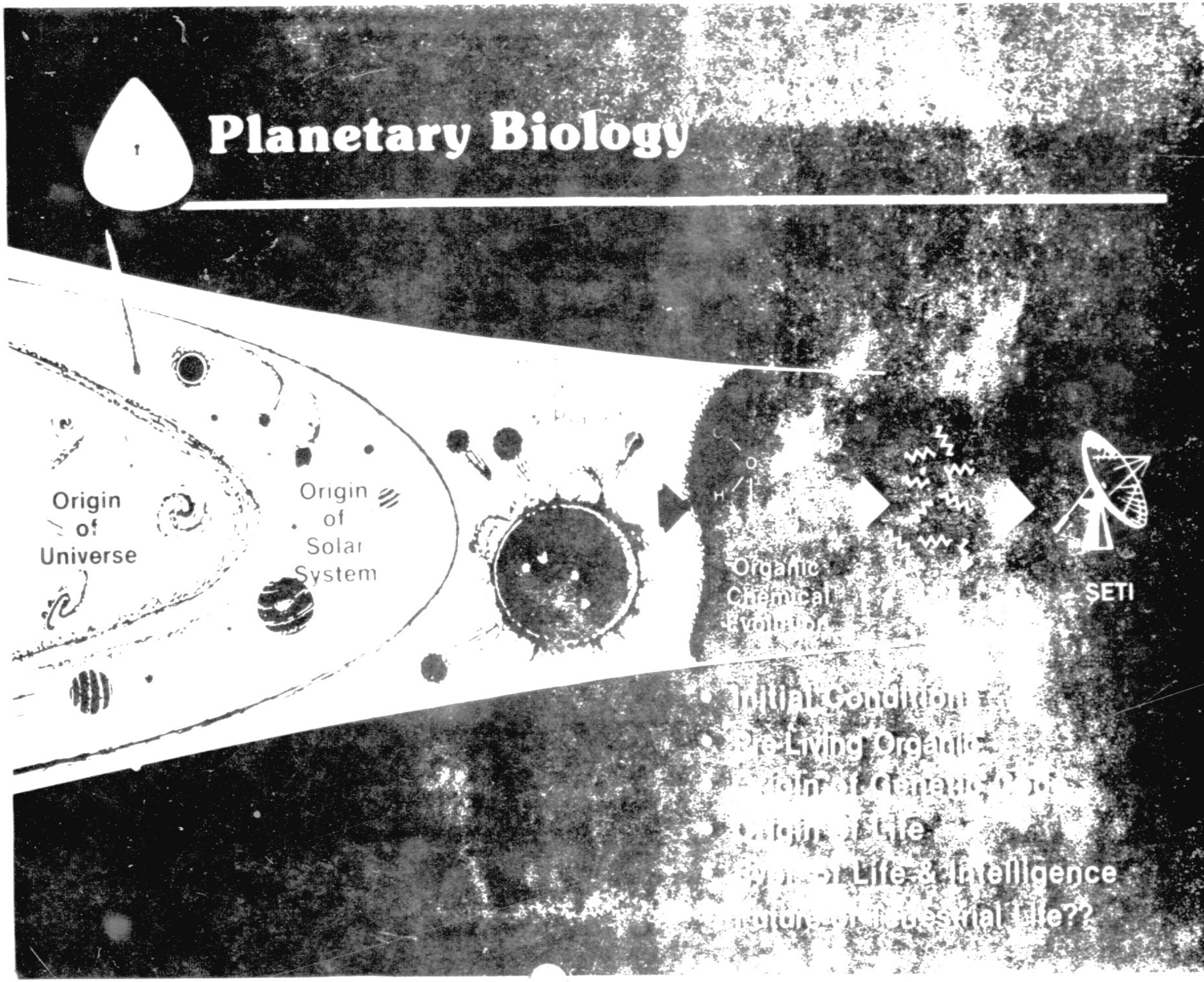
Space Motion Sickness

- Interferes With Scheduled Crew Time
- May Be Variant of Terrestrial Motion Sickness
- Characteristics:
  - — Onset Shortly After Entering Weightlessness
  - — Nausea, Cold Sweating, Pallor, Occasional Vomiting
  - — Slowly Subsides Over 2-3 Days
- Current Therapy Useful but Not Sufficiently Effective
- Biomedical Basis - Vestibular Disfunction/Sensory Conflict

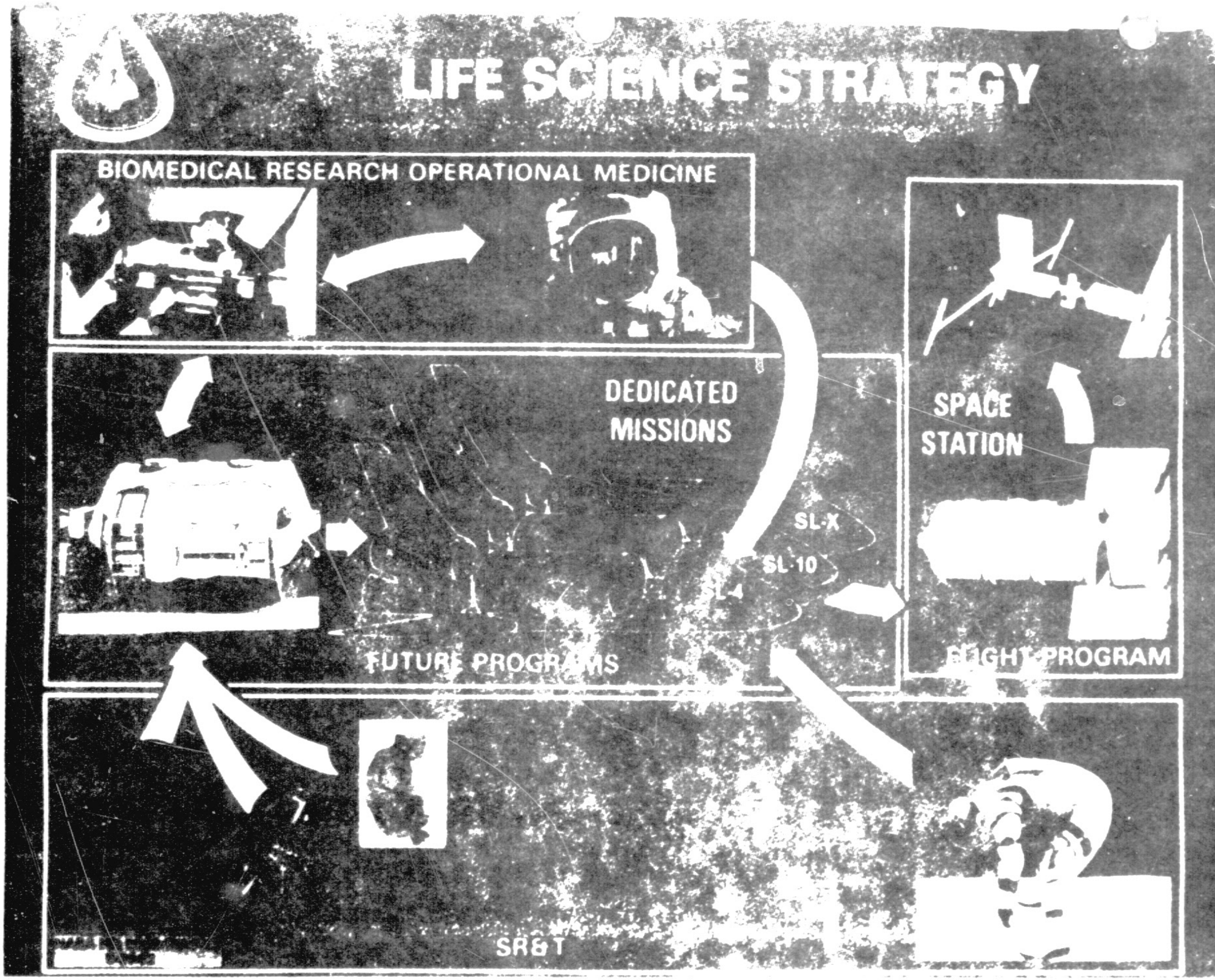

Motion Sickness
Treatment:
Drugs
(Scopdex)
Prediction
Treatment:
Biofeedback
Adaptation
Understanding
Vestibular
Mechanisms
NASA HQ EP82-1072 (3)
5-20-82

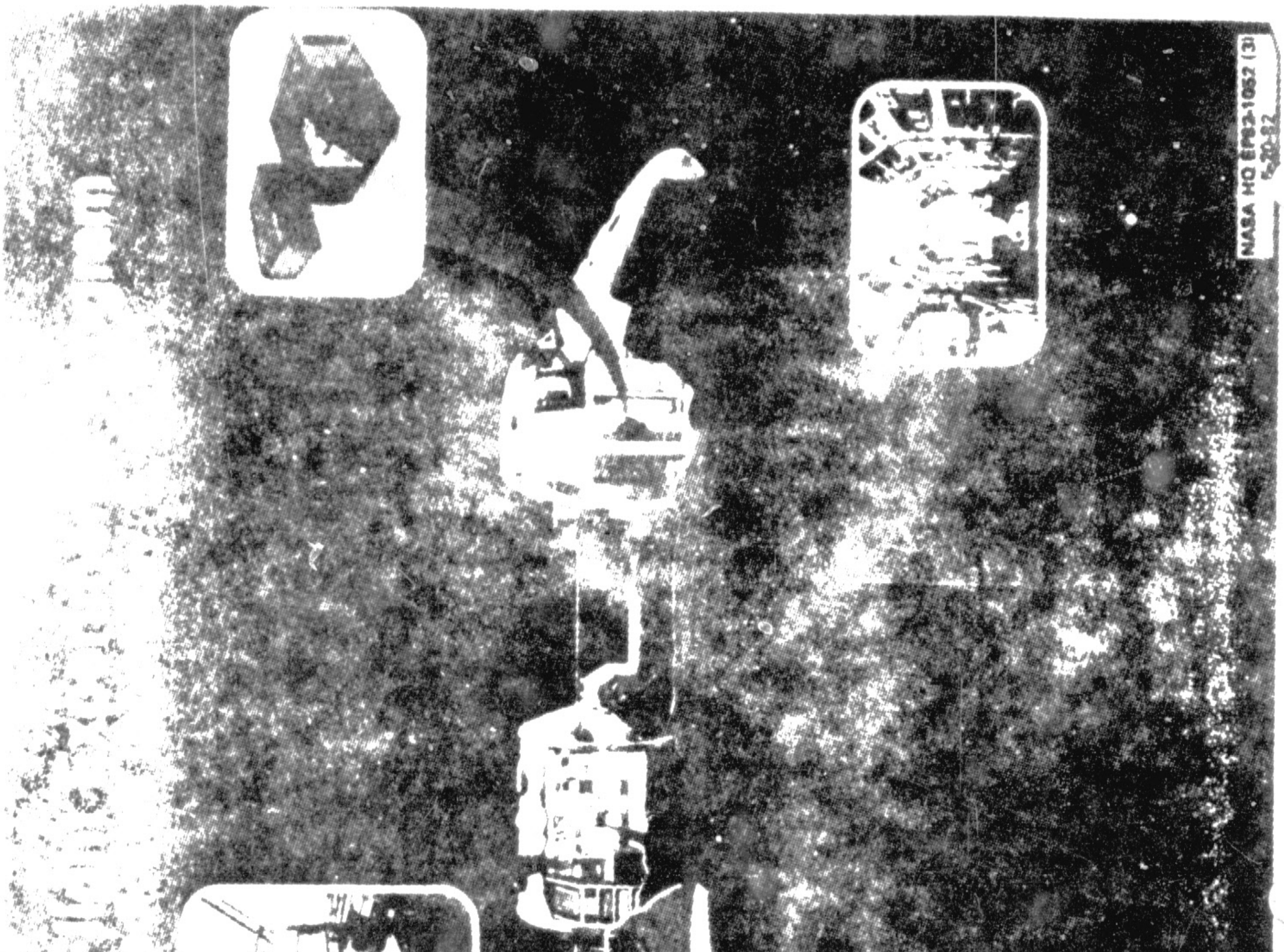

Gravitational
Response to g
Egg Development
• What Is the Basic Sensing Mechanism
• How Does It Work? & How Is It Mediated?
NASA HQ EP82-1063 (3)
5-20-82


Space Station
Regenerative Life Support System
Food
Water Vapor
Humidity Control
Drinking Water
Carbon Dioxide
Carbon Dioxide Collection, Reduction
Hydrogen
Hydrazine Dissociation
Nitrogen
Hydrazine
Methane
Hydrogen
Oxygen
Water Electrolysis
Water
Urine
Wash Water
Water Recovery
Only Food and Hydrazine Resupplied



Planetary Biology
Origin of Universe
Origin of Solar System
Organic Chemical Evolution
SETI
Initial Condition
Pre-Living Organic
Life & Intelligence


LIFE SCIENCE STRATEGY
BIOMEDICAL RESEARCH OPERATIONAL MEDICINE
DEDICATED
MISSIONS
SL-X
SL-10
SL-4
FUTURE PROGRAMS
SPACE
STATION
FLIGHT PROGRAM
SR&T



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Flight Experiments — LS-1

- Motion Sickness
- Cardiovascular
- Bone Changes
- Blood Changes
- Fluid Shifts
- Muscle Changes
- Amphibian Eggs
- Plant Geotropism

CONSIDERATIONS FOR THE SPACE STATION

- SCIENCE
- OPERATIONAL MEDICINE
- TESTS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

DATE: 9/14/82

ASSUMPTIONS

SPACE STATION

- o LEO/LOW INCLINATION
- o SHUTTLE SUPPORTED
- o CONTINUOUSLY MANNED. 4 CREWMEN
- o EVA - EIGHT PSI SUIT
- o MODULAR GROWTH CAPABILITIES

LIFE SCIENCES

- o SURGICAL TESTS PERFORMED
- o STAY TIME: CREW > 3 MONTHS; ANIMALS AS REQUIRED
- o LOW ACCELERATION (10^{-4}G) AVAILABLE

GENERAL

- o GLOBAL BIOLOGY AND BIOPROCESSING - COVERED ELSEWHERE
- o WARFARE HAZARDS AND PROTECTION - IGNORED

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

DATE: 9/14/82

TOP LEVEL CONSIDERATIONS

FACILITIES

- O HEALTH MAINTENANCE
  VIVARIA
  LABORATORIES - HUMANS AND ANIMALS
  GROUND SUPPORT

SPACE STATION CAPABILITIES

- O ON-BOARD DATA MANAGEMENT
- O ON-BOARD SAMPLE ANALYSIS
- O ARTIFICIAL GRAVITY
- O DATA TRANSMISSION
- O AUTOMATIC OPERATION OR CREW VISITATION TO ANIMALS/PLANTS
- O ON-BOARD CREW PHYSICAL FITNESS PROVISIONS
- O MAINTENANCE OF CREW PSYCHOLOGICAL WELL BEING
- O MEASUREMENT OF CREW PERFORMANCE

TOP LEVEL CONSIDERATIONS (CONT'D)

CREW SAFETY AND HEALTH

- O TREATMENT OF DECOMPRESSION
- O LIFE SUPPORT SYSTEM
- O MAXIMUM HABITABILITY
- O COMPARTMENTALIZATION
- O HABITAT PURGE/RECOMPRESSION

INTERFACE CONSIDERATIONS

- O PERIODIC RESUPPLY
- O ISOLATE CREW HABITAT FROM VIVARIA

SCIENTIFIC CONSIDERATIONS

- O HUMAN PHYSIOLOGICAL BASELINE SHIFTS (HUMAN & ANIMAL EXPERIMENTS)
  - CARDIOVASCULAR SYSTEM
  - MUSCULOSKELETAL METABOLISM
  - HEMATOLOGY AND IMMUNOLOGY
  - OTHERS
- O ANIMAL AND PLANT
  - REPRODUCTION AND GROWTH
  - PLANT - GRAVITY SENSORS

HABITABILITY CONSIDERATIONS

- o INTERNAL ENVIRONMENT
- o ARCHITECTURE
- o MOBILITY
- o CLOTHING
- o PERSONAL HYGIENE
- o HOUSEKEEPING
- o COMMUNICATIONS
- o CREW ACTIVITIES

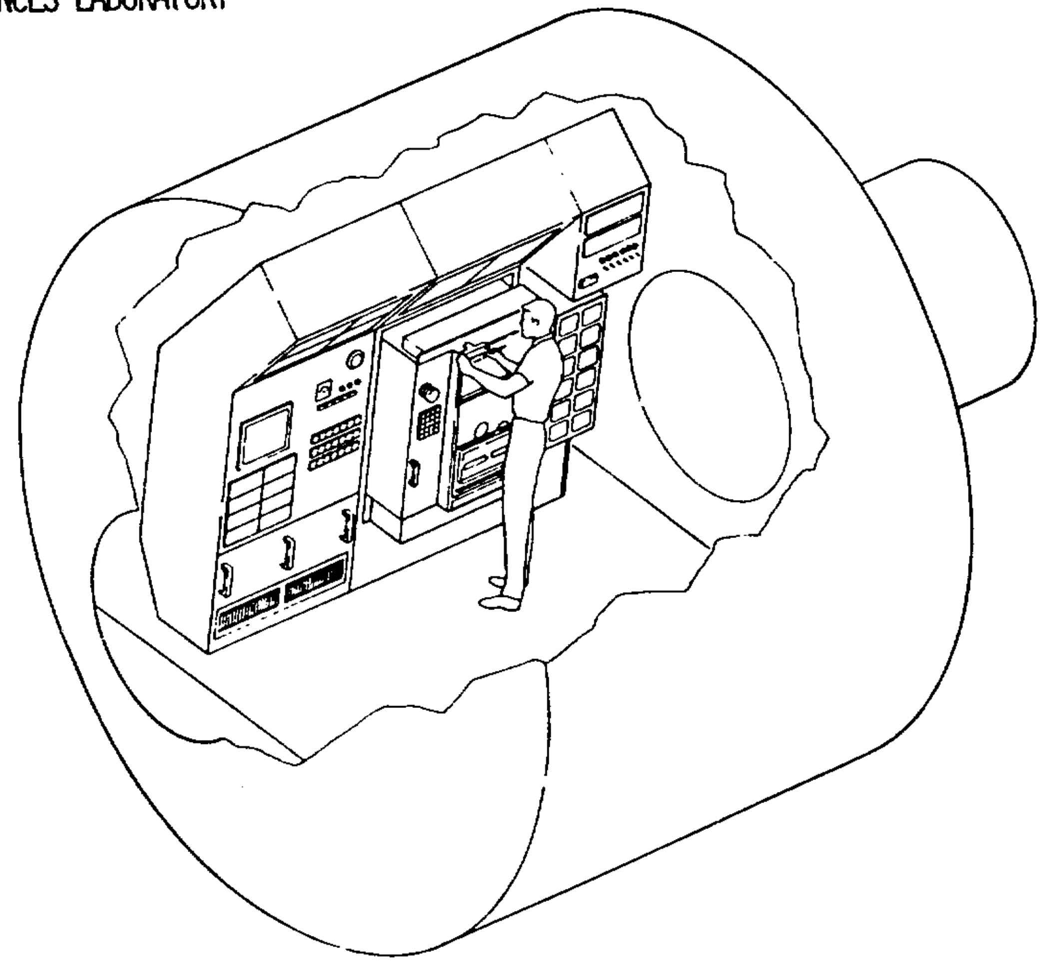
ADVANCED LIFE SUPPORT AND EVA SYSTEMS

- ALS
  - REGENERATIVE PROCESSES
  - TECHNOLOGY AND SUBSYSTEM DEVELOPMENT
- CELSS
  - NONBIOLOGICAL SUBSYSTEMS
  - BIOLOGICAL PROCESSES
  - LARGE SCALE TESTS
- EVA
  - MOBILITY
  - EXPERIMENTS

NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

DATE: 9/14/82

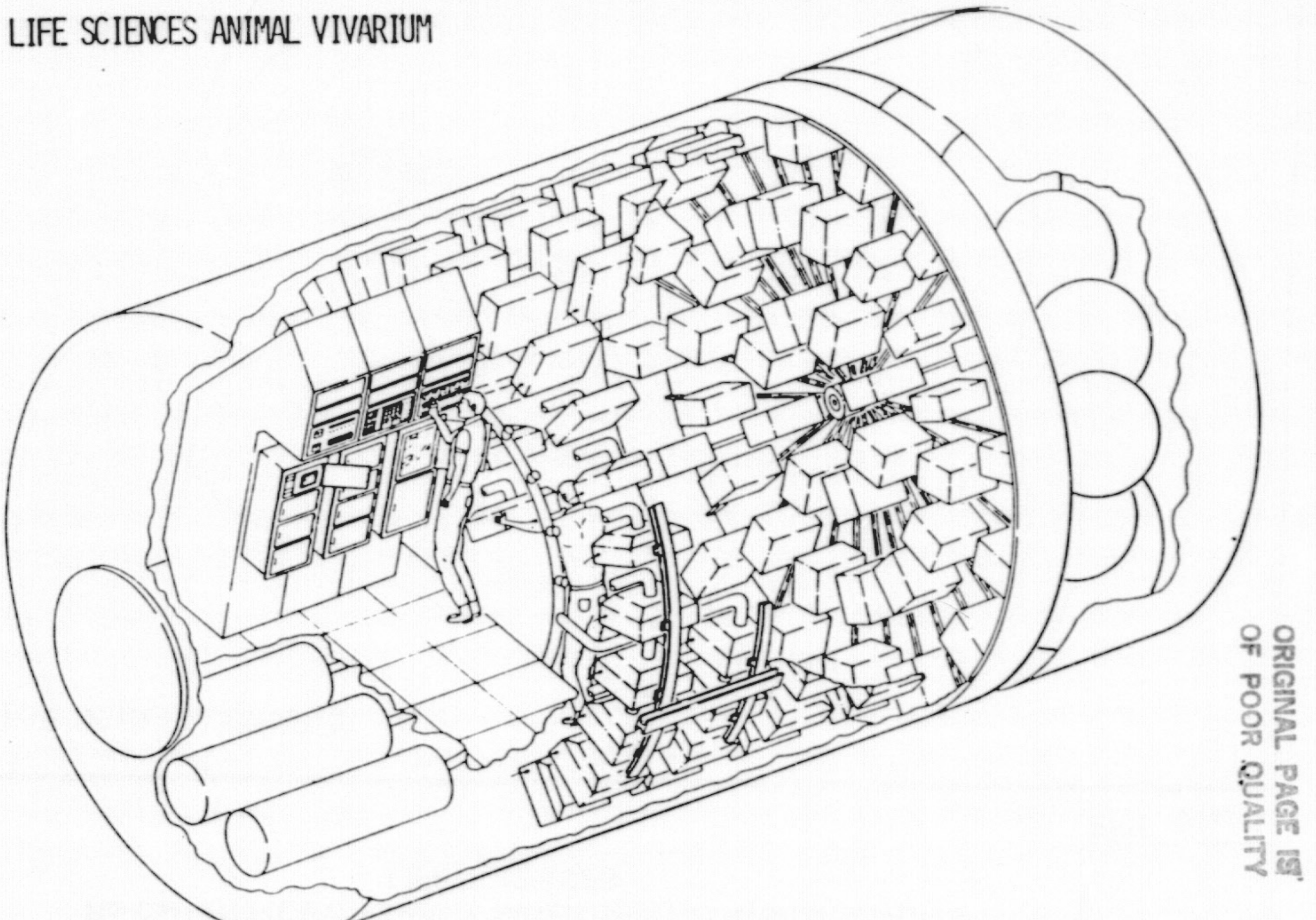
LIFE SCIENCES LABORATORY

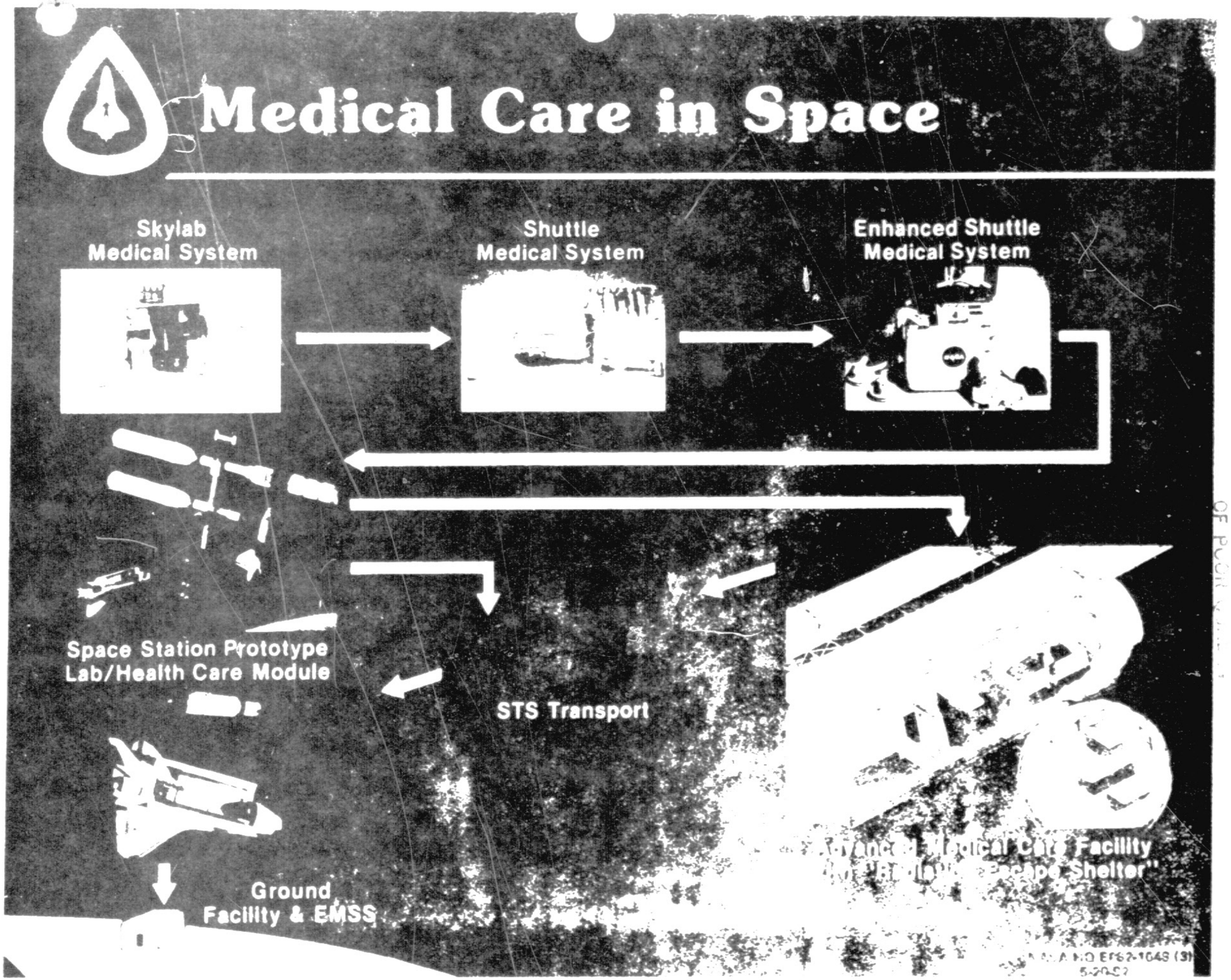


NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
LIFE SCIENCES

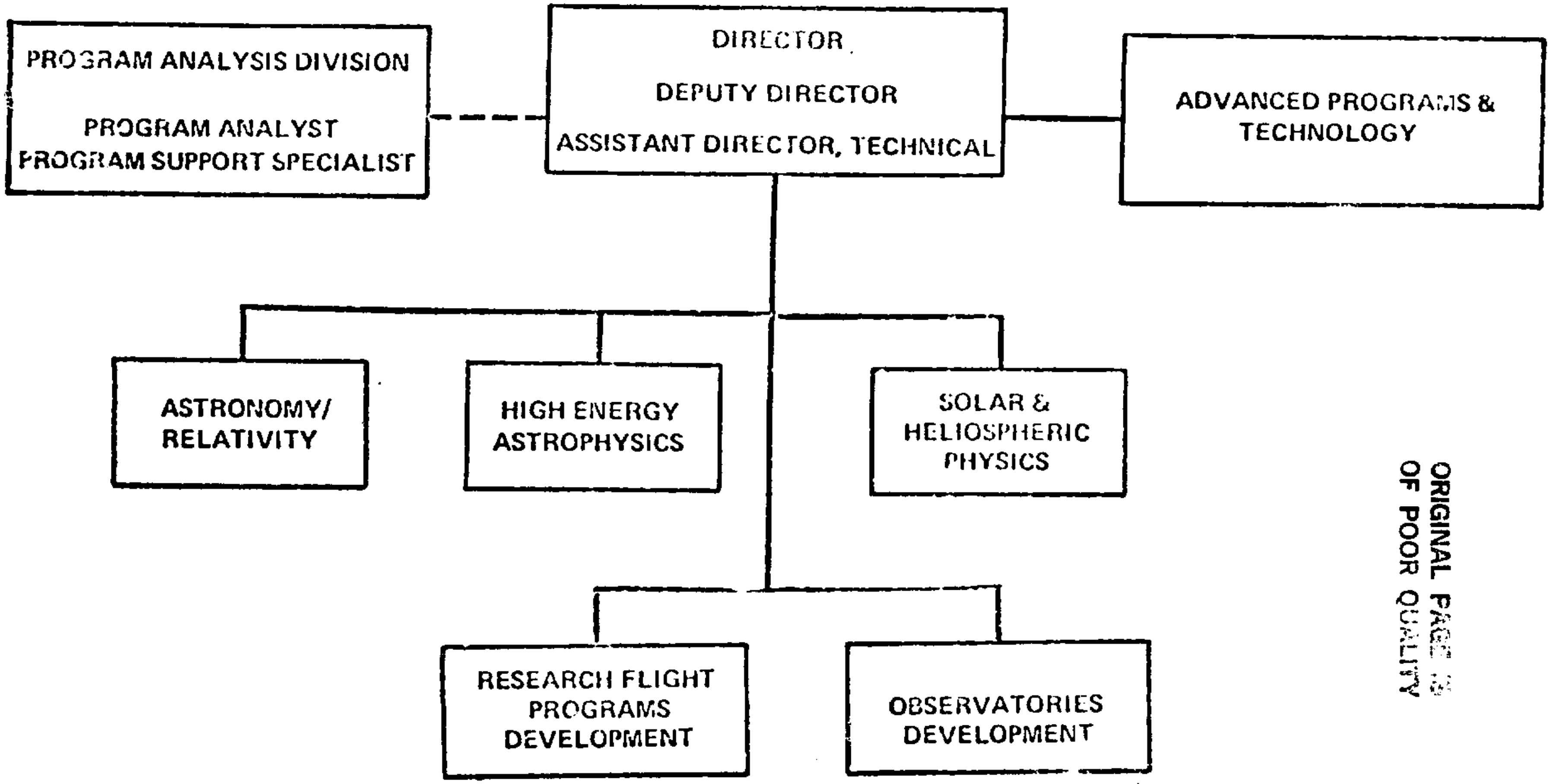
DATE: 9/14/82

LIFE SCIENCES ANIMAL VIVARIUM




Medical Care in Space
Skylab
Medical System
Shuttle
Medical System
Enhanced Shuttle
Medical System
Space Station Prototype
Lab/Health Care Module
STS Transport
Facility
Shelter"
Ground
Facility & EMSS

ASTROPHYSICS DIVISION



ASTROPHYSICS DIVISION

PROGRAM GOALS

TO UNDERSTAND:

- ORIGIN AND EVOLUTION OF THE UNIVERSE
- BASIC LAWS GOVERNING OBSERVED PHENOMENA
- SUN AS A STAR
- GENERATION OF ENERGY IN SUN
- ENERGY AND PLASMA TRANSPORTATION IN SOLAR WIND

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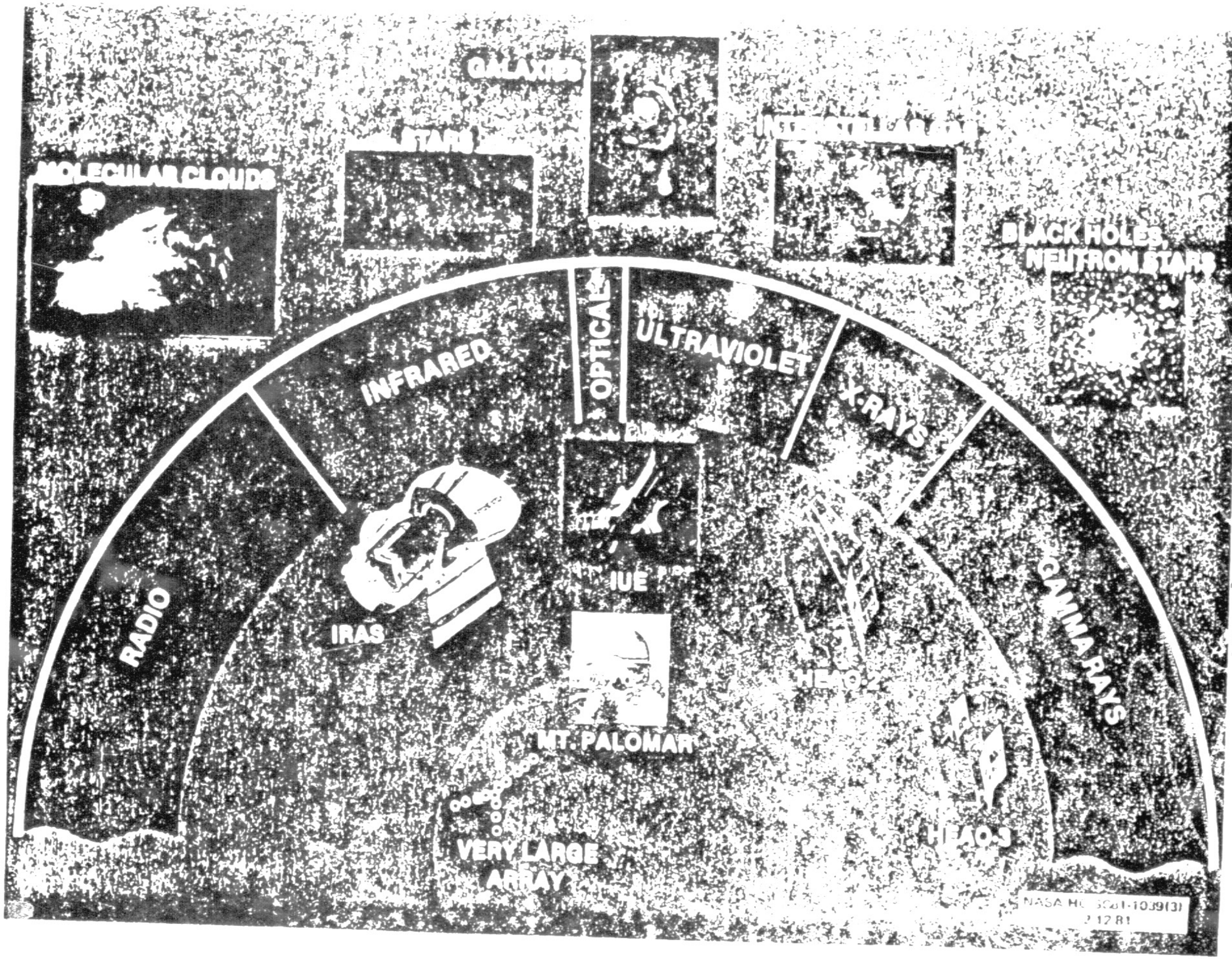
5-6-82


MOLECULAR CLOUDS
STARS
GALAXIES
BLACK HOLES
NEUTRON STARS
RADIO
INFRARED
OPTICAL
ULTRAVIOLET
X-RAYS
GAMMA RAYS
IRAS
IUE
MT. PALOMAR
VERY LARGE
ARRAY
HEAO-2
HEAO-3
NASA HQ
2-12-81

RATIONALE OF THE ASTROPHYSICS PROGRAM

USE SPACE TO REMOVE LIMITATIONS

- WAVELENGTH COVERAGE
- ANGULAR RESOLUTION
- TEMPORAL RESOLUTION
- SENSITIVITY

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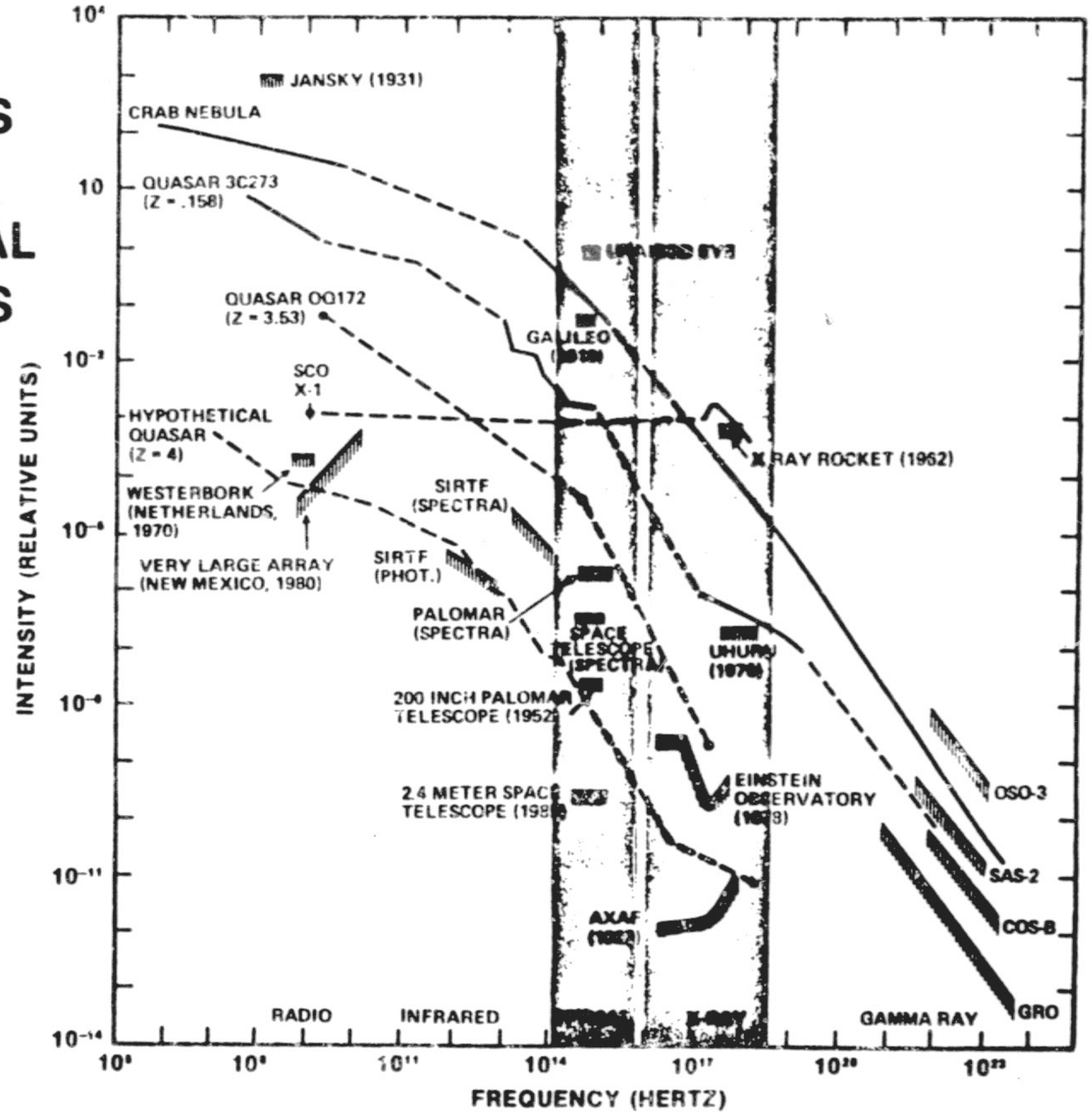
SENSITIVITIES OF ASTRONOMICAL INSTRUMENTS



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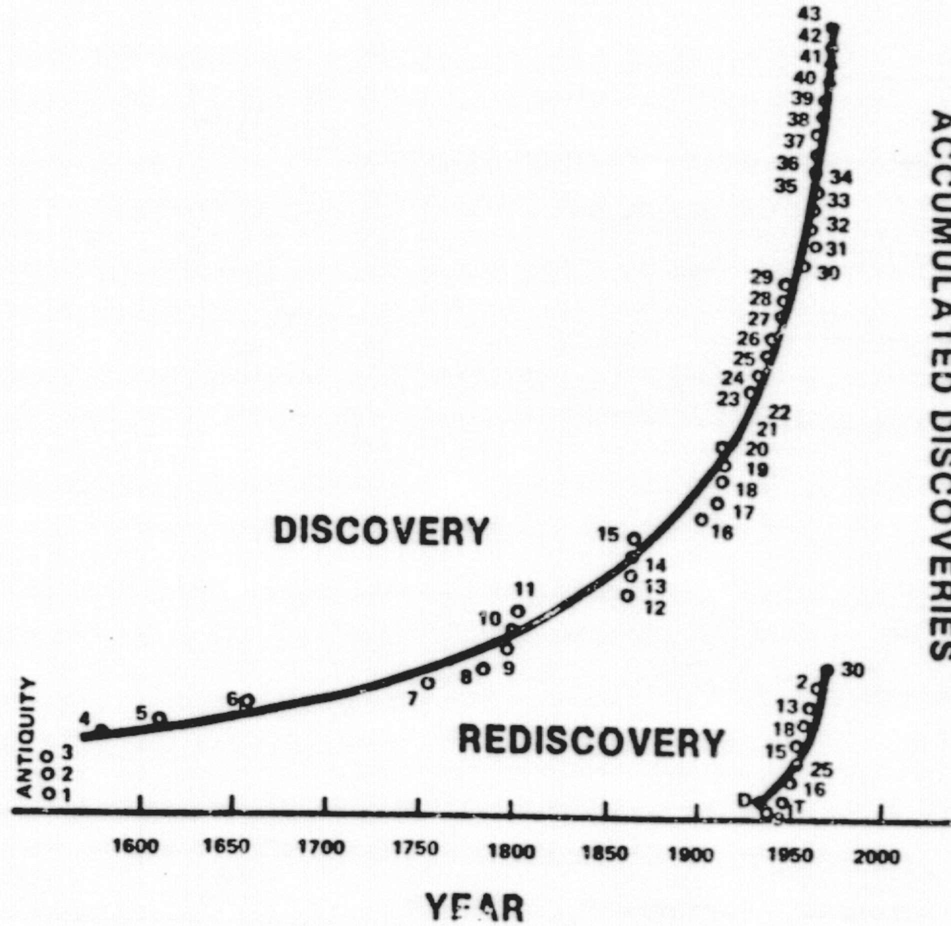
ASTROPHYSICAL DISCOVERY

1 STARS
2 PLANETS
3 NOVAS
4 COMETS
5 MOONS
6 RINGS
7 GALACTIC CLUSTERS
8 CLUSTERS OF GALAXIES
9 INTERPLANETARY MATTER
10 ASTEROIDS
11 MULTIPLE STARS
12 VARIABLE STARS WITH NEBULOSITY
13 PLANETARY NEBULAS
14 GLOBULAR CLUSTERS
15 IONIZED GAS CLOUDS
16 COLD INTERSTELLAR GAS
17 GIANTS/MAIN SEQUENCE STARS
18 COSMIC RAYS
19 PULSATING VARIABLES
20 WHITE DWARFS
21 GALAXIES
22 COSMIC EXPANSION
23 INTERSTELLAR DUST
24 NOVAE/SUPERNOVAE
25 GALAXIES WITH/WITHOUT GAS
26 SUPERNOVA REMNANTS
27 RADIO GALAXIES
28 MAGNETIC VARIABLES
29 FLARE STARS
30 INTERSTELLAR MAGNETIC FIELDS
31 X-RAY STARS
32 X-RAY BACKGROUND
33 QUASARS
34 MICROWAVE BACKGROUND
35 MASERS
36 INFRARED STARS
37 X-RAY GALAXIES
38 PULSARS
39 GAMMA-RAY BACKGROUND
40 INFRARED GALAXIES
41 SUPERLUMINAL SOURCES
42 GAMMA-RAY BURSTS
43 UNIDENTIFIED RADIO SOURCES



THRUSTS IN ASTROPHYSICS

	DATA BASE	TYPICAL PROBLEMS	FIRST CUT	INITIAL SURVEY	DETAILED STUDY	MATURE OBSERVATORY	OBSERVATORY SUPPORT	SPECIALIZED TECHNIQUES
HIGH ENERGY	COSMIC RAYS	FORMATION OF ELEMENTS	BALLOONS	SPACELAB HEAO-3	COSMIC RAY OBSERVATORY			
	GAMMA RAYS	PULSARS INTERSTELLAR GAS (LOCATION)	BALLOONS	SMALL ASTRONOMY SATELLITE-B HEAO-3	GAMMA-RAY OBSERVATORY			
	X RAYS	INTERGALACTIC MATTER	ROCKETS	UHURU HEAO-1	HEAO-2	AXAF	HTM	X RAY TIMING EXPLORER
	SOFT X-RAYS	INTERSTELLAR GAS (COMPOSITION)	ROCKETS	HEAO-1				
ASTRONOMY	EXTREME ULTRAVIOLET	DYING STARS	APOLLO SOYUZ TEST PROJECT	EUV EXPLORER				
	ULTRAVIOLET	HOT STARS	ROCKETS	ORBITING ASTRONOMY OBSERVATORY-1 (OAO-1)	OAO-3 INTERNATIONAL ULTRAVIOLET EXPLORER	FUSE	STARLAB	
	VISIBLE	QUASARS, NORMAL STARS				SPACE TELESCOPE		
	INFRARED (WARM OPTICS)	IONIZED GAS, GALACTIC CENTER MOLECULES	BALLOONS	AIRBORNE		LDR		
	INFRARED (COLD OPTICS)	INTERSTELLAR DUST	BALLOONS ROCKETS	SPACELAB IRAS / COBE	SIRTF			
	MICROWAVES	BIG BAND	AIRBORNE BALLOONS	COBE				
	RADIO	EXPLODING GALAXIES, INTERSTELLAR ELECTRONS		RADIO ASTRONOMY EXPLORER-A, B	OVLBI	VLA		
	RELATIVITY	NATURE OF GRAVITY						GRAVITY PROBE-B

GROUND BASED

APPROVED PROGRAMS

NEW EXPLORERS

SHUTTLE/PLATFORM FACILITIES

FREE FLYER NEW START

POST 88 NEW START

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THRUSTS IN SOLAR PHYSICS

	FIRST CUT	INITIAL SURVEY	DETAILED STUDY	MATURE OBSERVATORY	SPECIALIZED TECHNIQUES
INTERIOR	STAR PROBE GROUND BASED & SMM	SIOM	SIOM		STAR PROBE SOLAR BEACON
QUIET SURFACE	GROUND BASED OSO 1-6	SKYLAB OSO 8	OSO-8	SOT XUVTF PDF	STAR PROBE SPACE LAB
SOLAR ACTIVITY	ROCKET GROUND BASED & OSO 1-6	SKYLAB OSO 7 & 8	SSM	SOT SSXRT PDF	SPACE LAB
TRANSPORT TO CORONA	ROCKET GROUND BASED & OSO 1-6	SKYLAB OSO 7 & 8 SMM	SCOM	SOT XUVTF	SPACE LAB
CORONAL STRUCTURES	GROUND BASED & ROCKET	SKYLAB OSO-7	SCOM SIS	SSXRT XUVTF PDF	STAR PROBE
TRANSPORT TO SOLAR WIND	OSO-7	SKYLAB OSO-7	SCOM SIS	SSXRT PDF	STAR PROBE
3-DIMENSIONAL HELIOSPHERIC STRUCTURE	MARINER PIONEER	PIONEER, IMP VOYAGER ISEE	ISPM SCOM SIS		
SOLAR-TERRESTRIAL	EARLY EXPLORERS	ISEE, SMM ISPM	SIS OPEN UARS	STO	

APPROVED PROGRAM

POST 87 NEW STARTS

ADVANCED SOLAR OBSERVATORY

NEW MISSIONS

NEW SHUTTLE/ PLATFORM FACILITIES

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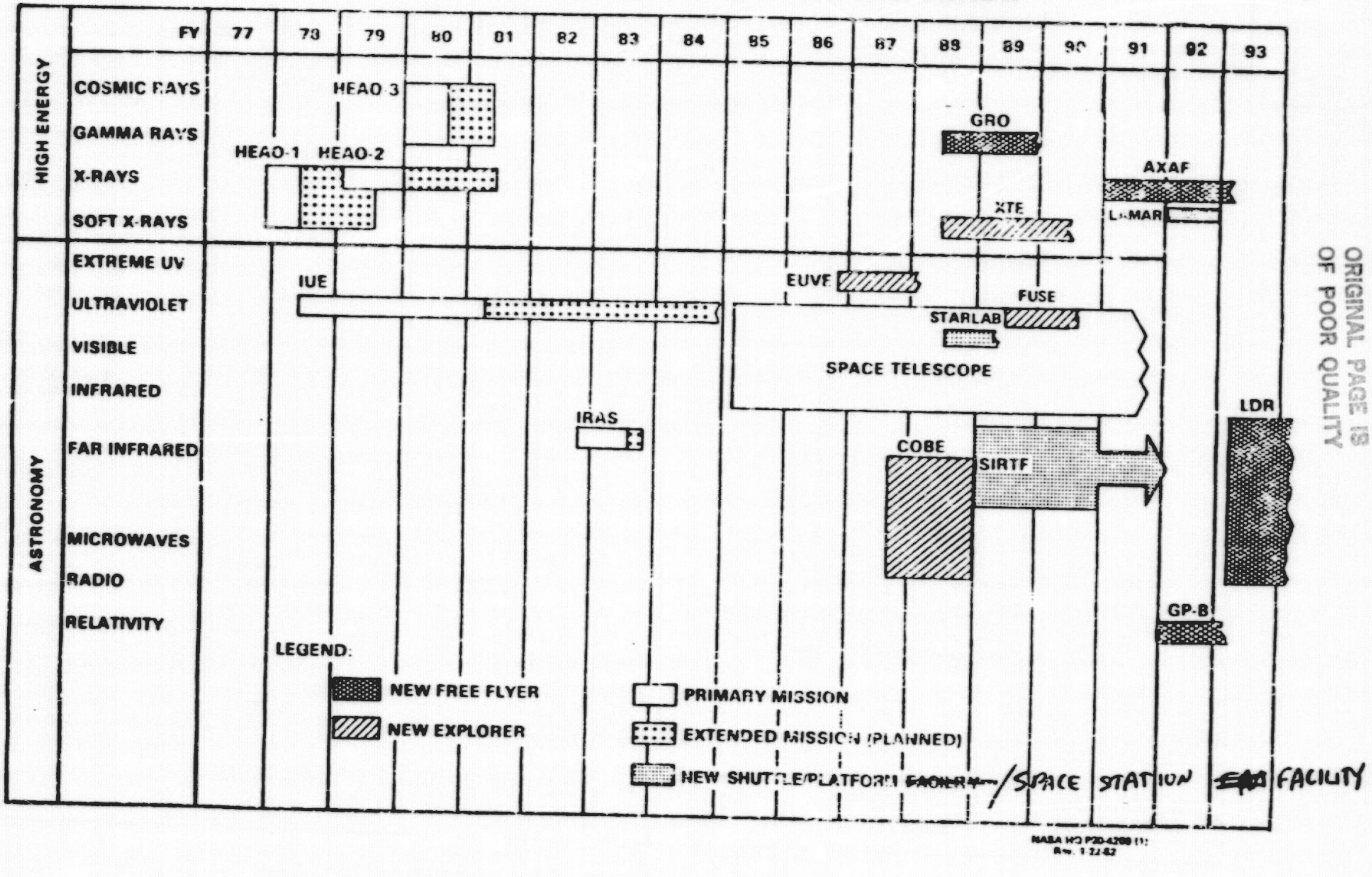
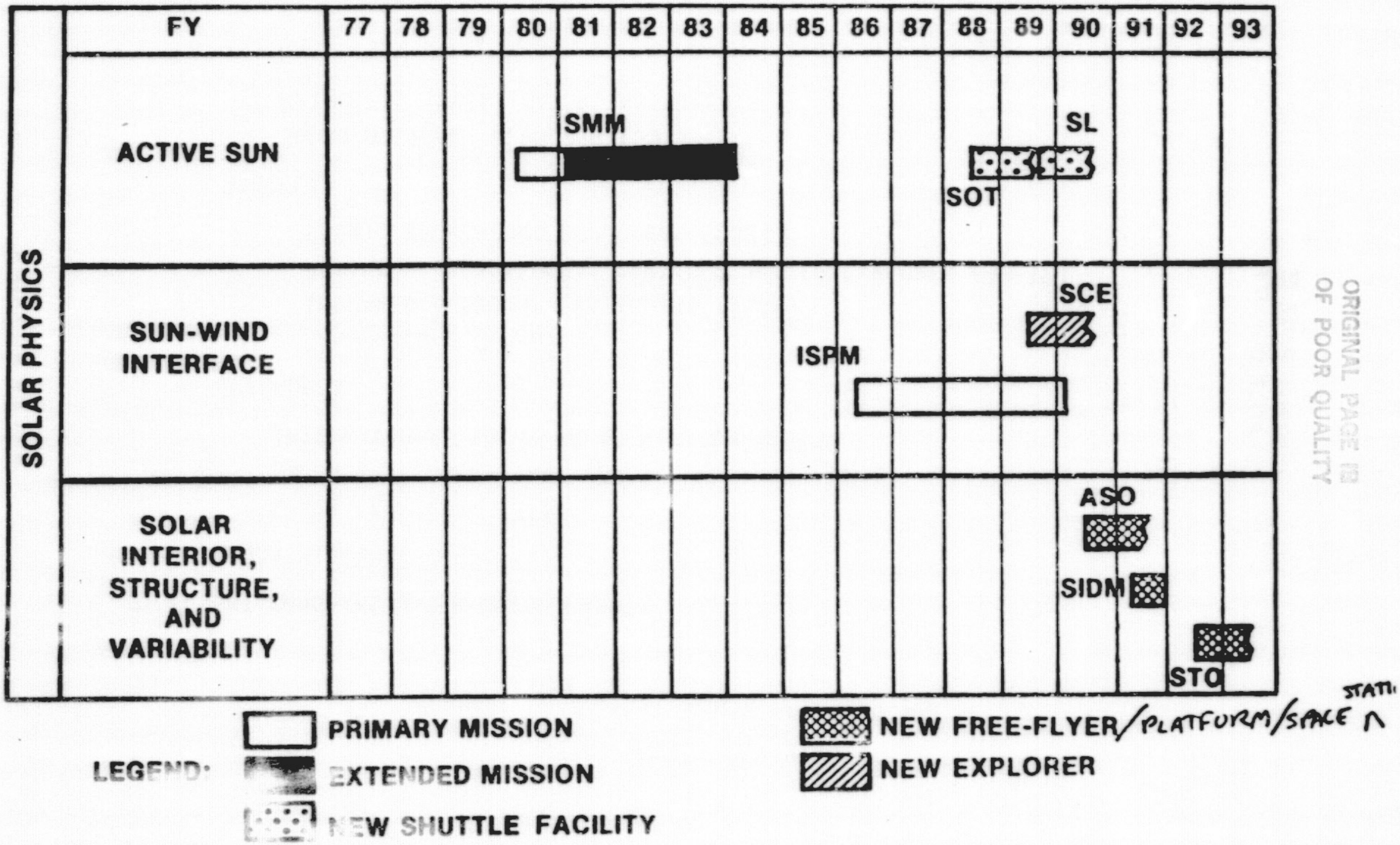
MAJOR MISSIONS TO STUDY THE UNIVERSE



MAJOR MISSIONS TO STUDY SOLAR PHYSICS



ASTROPHYSICS DIVISION

CURRENT PROGRAM ELEMENTS (FY 1982-1983)

- FLIGHT PROGRAMS UNDER DEVELOPMENT
  - MAJOR MISSIONS

    SPACE TELESCOPE (ST)
    GAMMA RAY OBSERVATORY (GRO)
    INTERNATIONAL SOLAR POLAR MISSION (ISPM)

  - EXPLORERS

    SAN MARCO-D (SM-D)
    INFRARED ASTRONOMY SATELLITE (IRAS)
    ACTIVE MAGNETOSPHERIC PARTICLE TRACER EXPLORER (AMPTE)
    COSMIC BACKGROUND EXPLORER (COBE)

  - SPACELAB

    SOLAR OPTICAL TELESCOPE (SOT)
    PRINCIPAL INVESTIGATOR INSTRUMENTS

ASTROPHYSICS DIVISION

ASTRONOMY SURVEY COMMITTEE (FIELD COMMITTEE)

RECOMMENDATIONS RELEVANT TO NASA PROGRAMS

MAJOR NEW PROGRAMS

- ADVANCED X-RAY ASTROPHYSICS FACILITY
- LARGE DEPLOYABLE REFLECTOR IN SPACE

MODERATE NEW PROGRAMS

- AUGMENTATION TO EXPLORER PROGRAM
- FAR-ULTRAVIOLET SPECTROGRAPH IN SPACE
- SPACE VERY LONG-BASELINE INTERFEROMETRY ANTENNA
- ADVANCED SOLAR OBSERVATORY
- COSMIC RAY EXPERIMENTS IN SPACE
- ASTRONOMICAL SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE

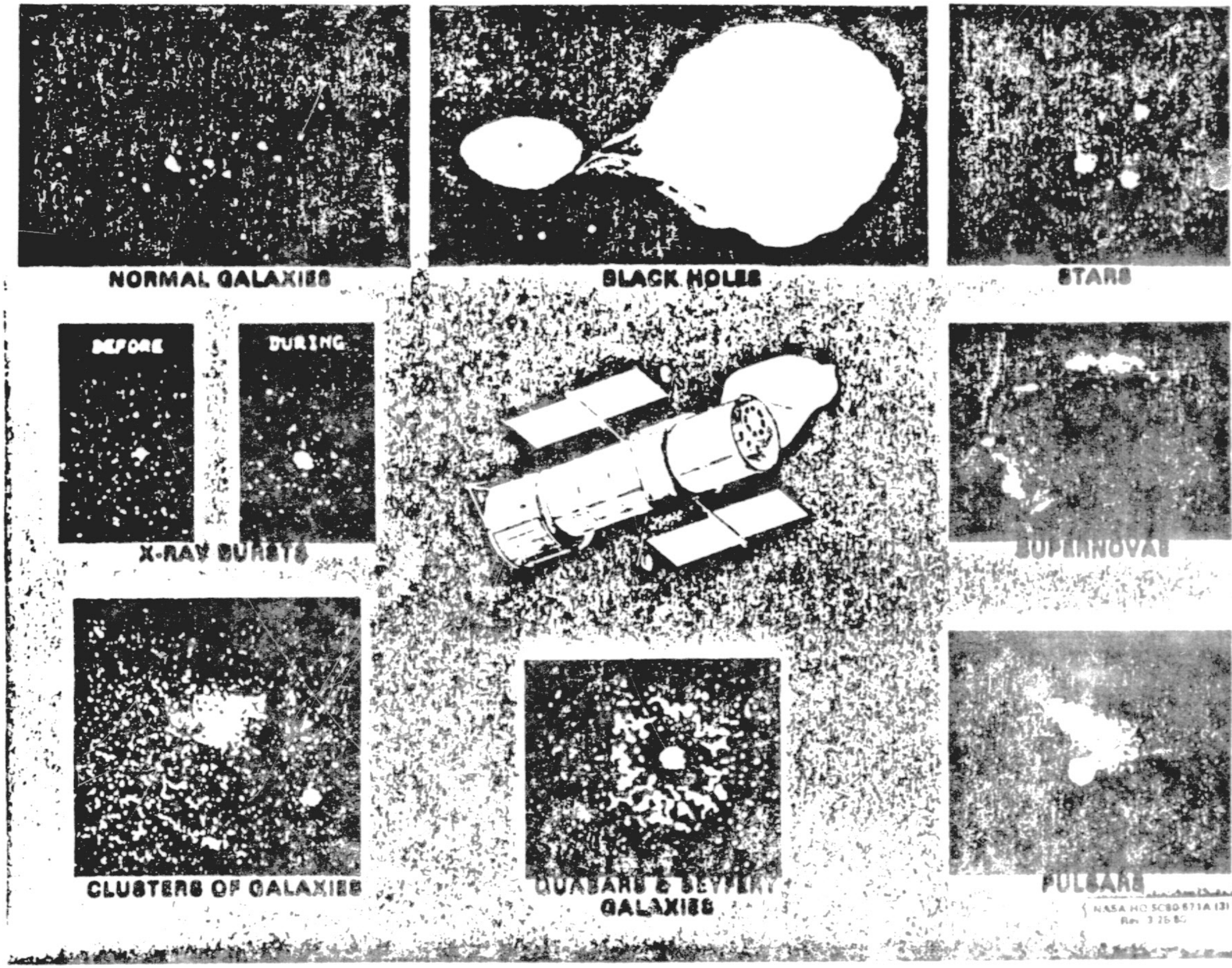
PROGRAMS FOR STUDY AND DEVELOPMENT

- FUTURE X-RAY OBSERVATORY IN SPACE
- GRAVITY WAVE DETECTOR
- LONG DURATION SPACE FLIGHT OF CRYOGENICALLY COOLED INFRARED TELESCOPES
- VERY LARGE TELESCOPE IN SPACE
- ADVANCED INTERFEROMETRY
- ADVANCED GAMMA-RAY EXPERIMENTS
- ASTRONOMICAL OBSERVATORIES ON THE MOON

ASTROPHYSICS DIVISION

FUTURE PROGRAMS

- MAJOR FLIGHT MISSIONS
  - ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)
  - DEPLOYABLE IR AND SUB MM ANTENNA
- MODERATE FLIGHT MISSIONS
  - GRAVITY PROBE-B
  - SOLAR INTERNAL DYNAMICS MISSION
- EXPLORERS
  - EXTREME ULTRAVIOLET EXPLORER
  - X-RAY TIMING EXPLORER
- SPACELAB/SPACE STATION
  - SHUTTLE INFRARED TELESCOPE FACILITY (SIRTF)
  - STARLAB
  - PRINCIPAL INVESTIGATOR INSTRUMENTS

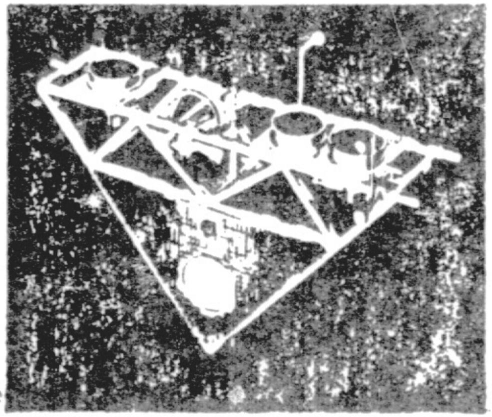

NORMAL GALAXIES
BLACK HOLES
STARS
BEFORE
DURING
X-RAY BURSTS
SUPERNOVAE
CLUSTERS OF GALAXIES
QUASARS & SEYFERT
GALAXIES
PULSARS

Advanced X-Ray Astrophysics Facility (AXAF)

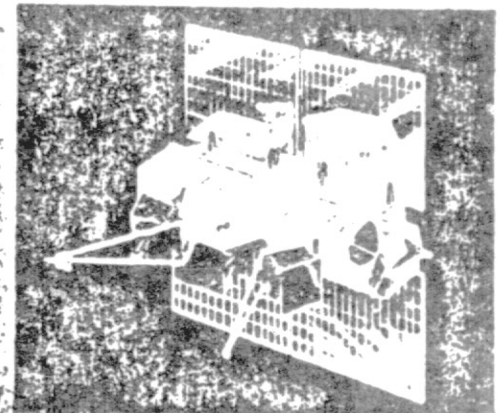
Status

Objective:	To provide a major X-ray observatory for long term, high sensitivity and high resolution astronomical research.
Recommended By:	NAS/Astronomy Survey Committee (Field Committee) NAS/Committee on Space Astronomy and Astrophysics
Study Phase:	Concept Feasibility (1978) Science Working Group Report (1980) Extended Phase A Study (FY 82) Technology Development (FY 82-83) Contracted Phase B Studies (FY 84-85)
AO Release:	March 1983
Start Candidate:	FY 1986
Launch:	1991

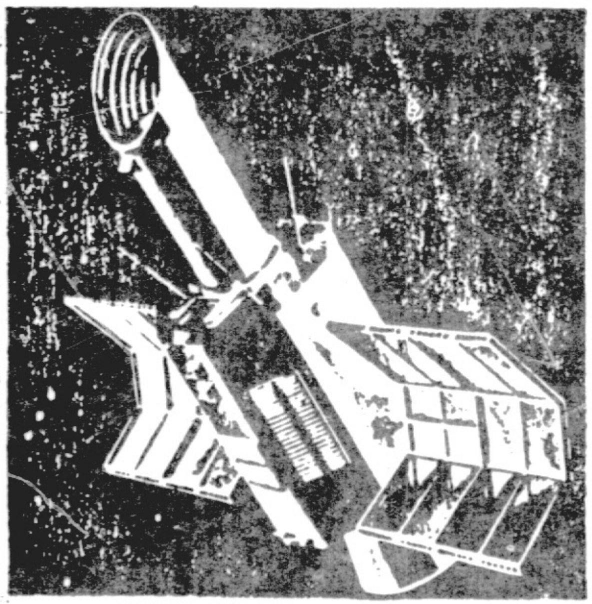
FUTURE EXPLORERS



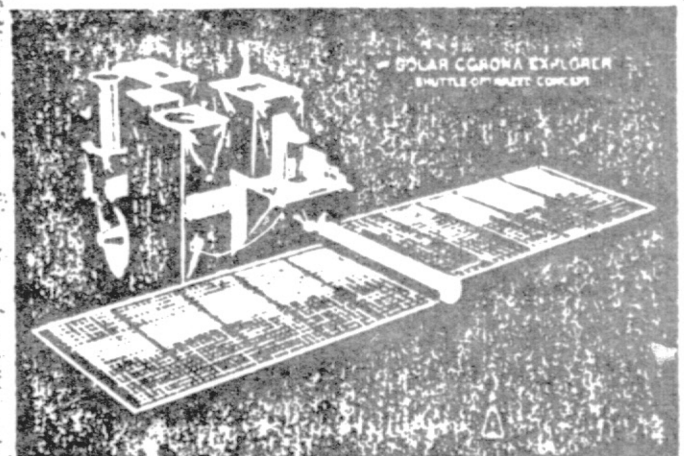
EXTREME ULTRAVIOLET EXPLORER



X-RAY TIMING EXPLORER



FAR ULTRAVIOLET SPECTROSCOPY EXPLORER



SOLAR CORONA EXPLORER

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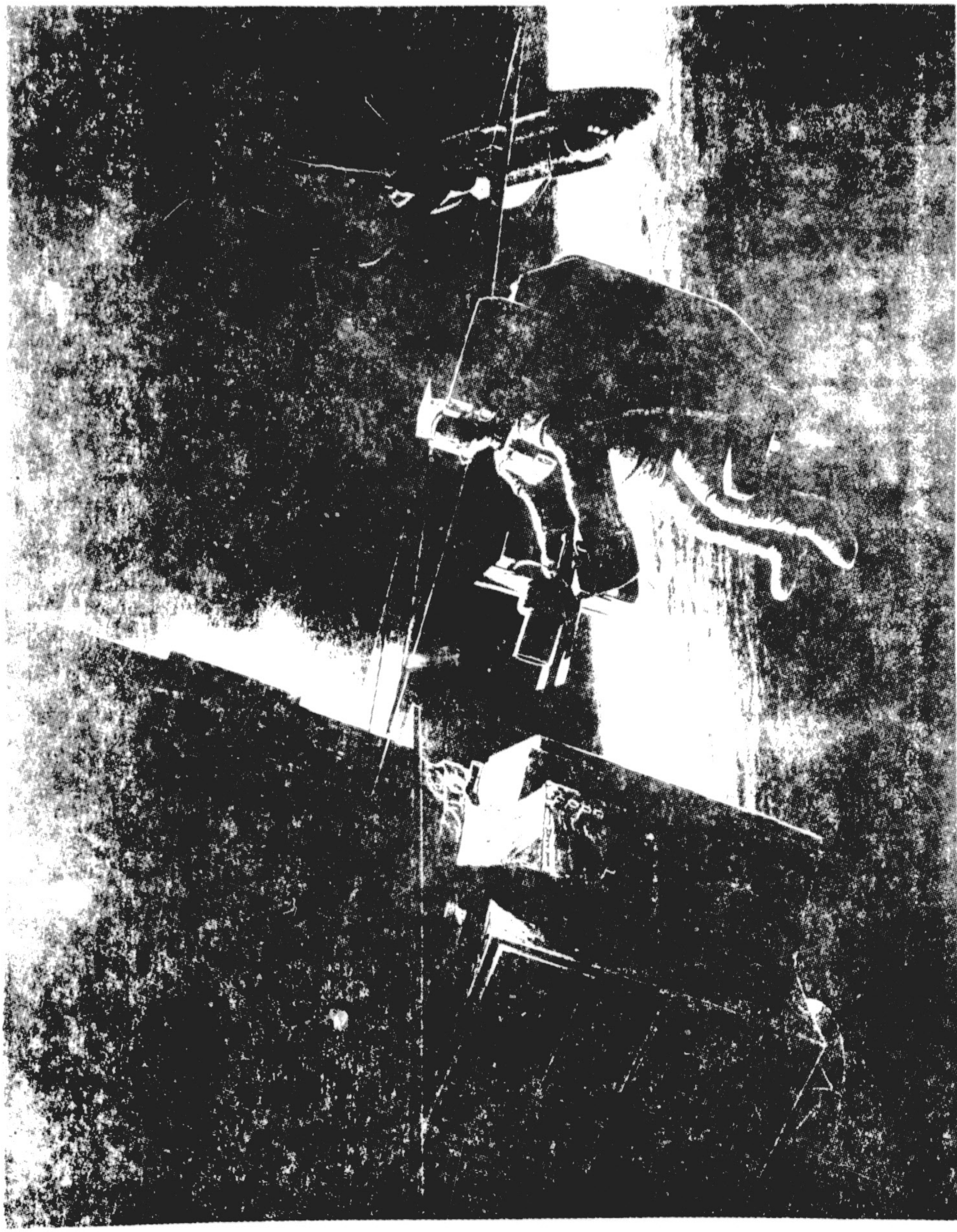
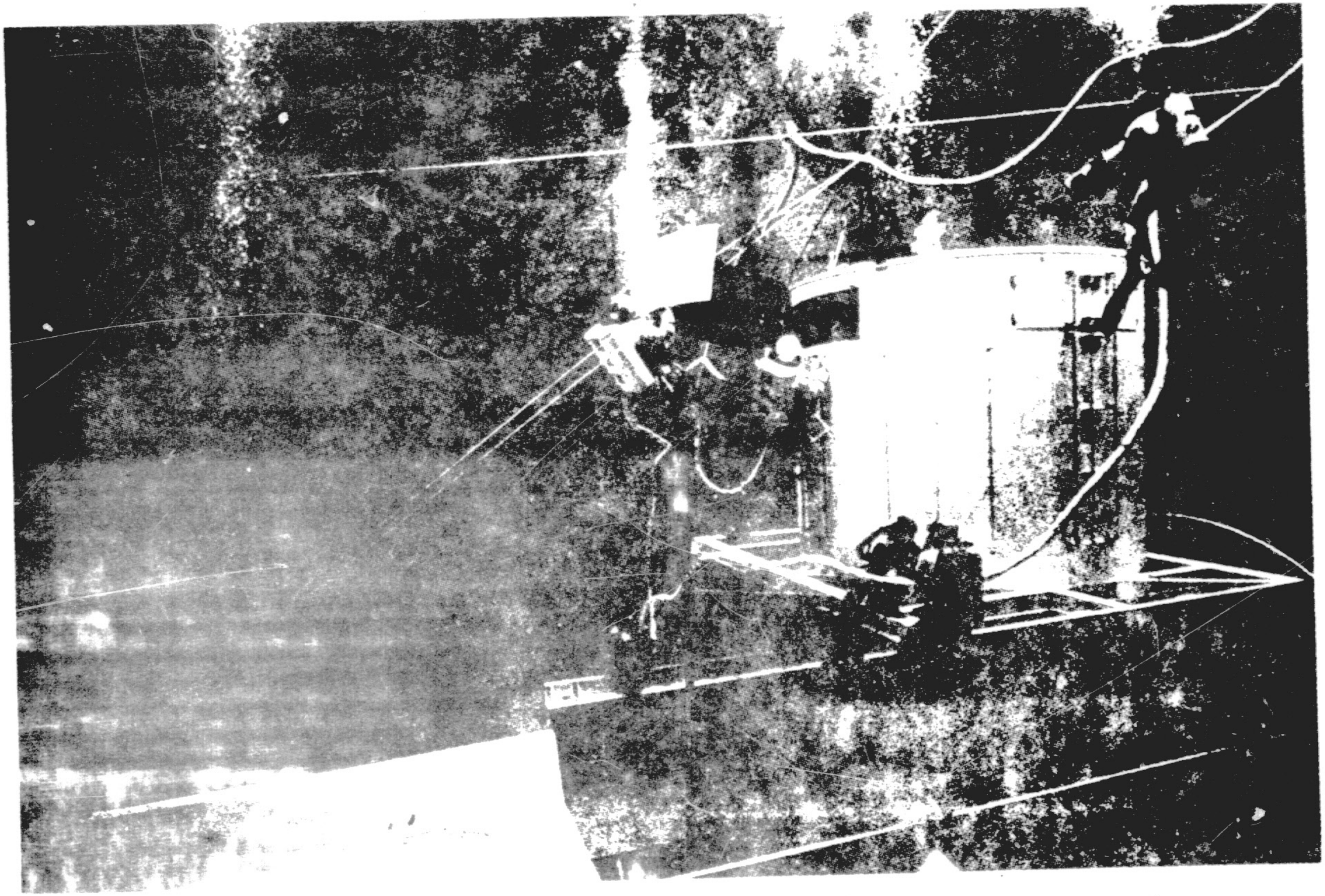
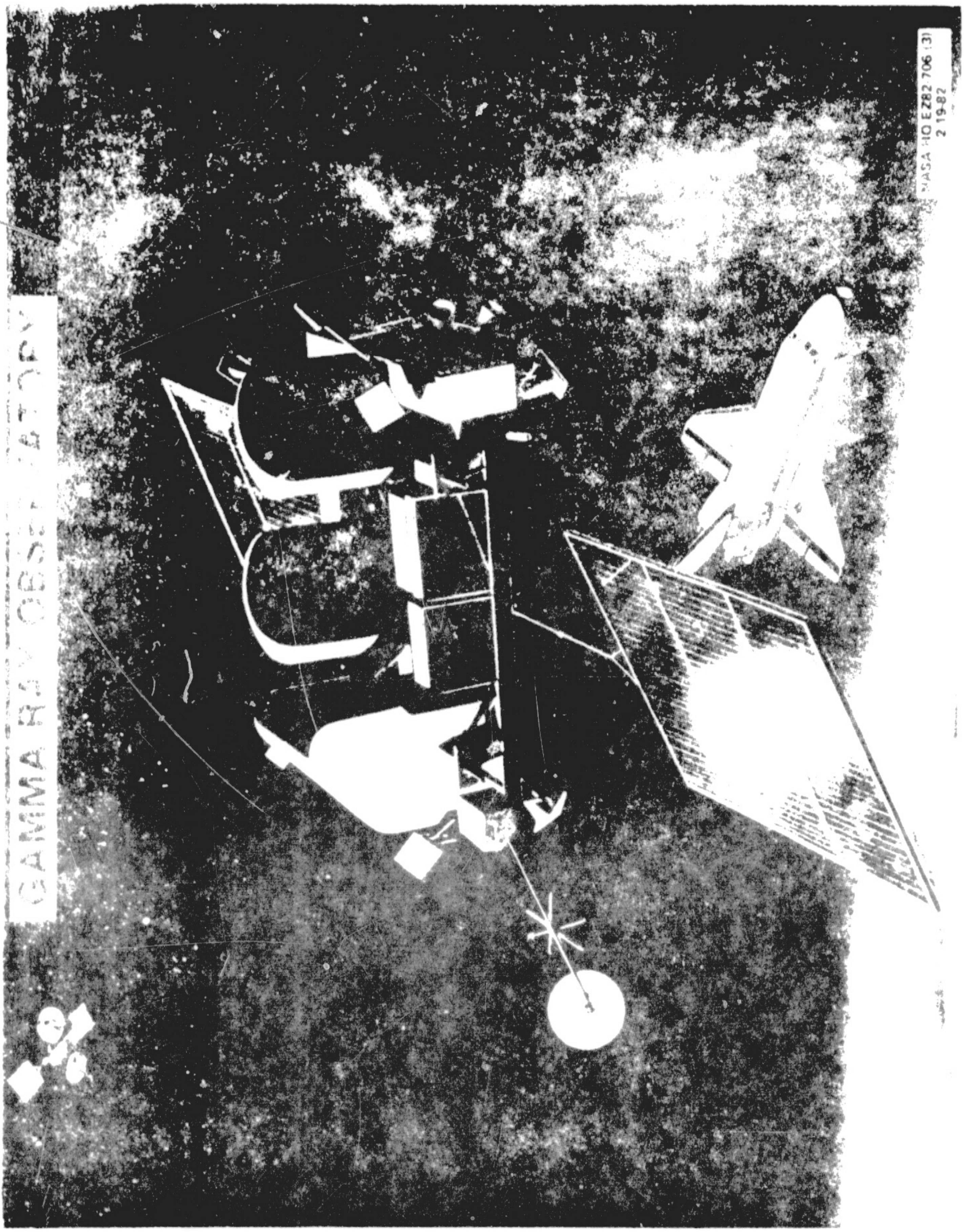
5-6-82



SPACE TELESCOPE — WIDE FIELD CAMERA MOCK-UP REMOVAL IN NEUTRAL BUOYANCY FACILITY

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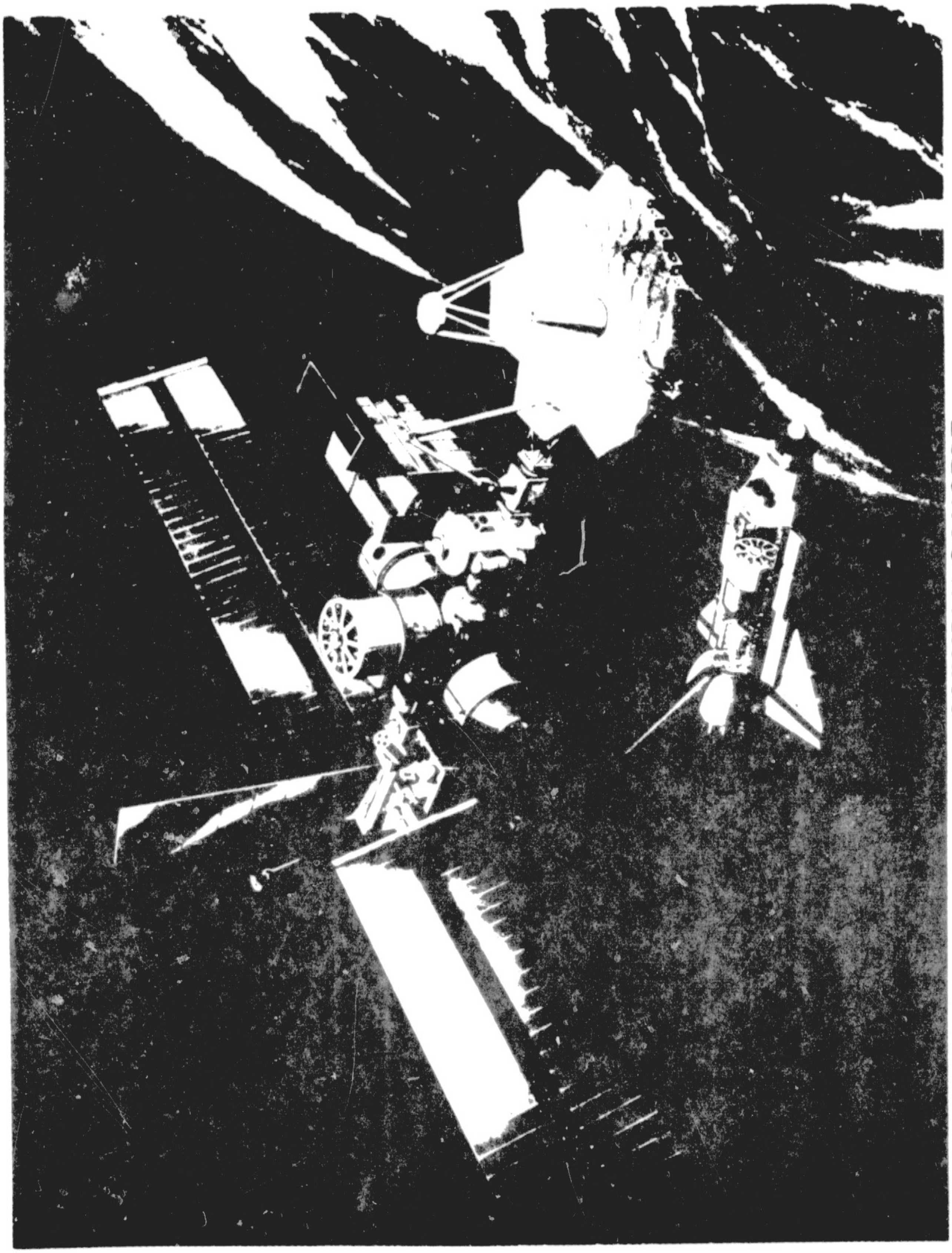
ADVANCED X-RAY
ASTROPHYSICS FACILITY



LDR ASSEMBLY CONCEPT

Requirements for Astrophysics Investigations That Might Be Conducted From a Space Station

I UV-optical astronomy

	Typical	Limiting
Preferred orbital inclination	28.5	28.5
Pointing direction	Celestial	Celestial
Pointing accuracy	2 min	5 sec (FUSE)
Pointing stability	10 sec	2 sec (FUSE)
Data rates	100 kbps	1 Mbps (Starlab)
Power	1 kW	2 kW (Starlab)
Mass	1000 kg	1800 kg
Revisit interval	Not critical	
Real-time ops?	Some for target acquisition	
Major susceptibilities	Materials that can condense on optics; particles or gas that scatter ultraviolet light	
Thermal	100 W	200 W (Starlab)
Manned services required/desired?	None	Small repairs

II Infrared-radio astronomy

	Typical	Limiting
Preferred orbital inclination	28.5	57.0 (OVLBI)
Pointing direction	Celestial	Celestial
Pointing accuracy	2 min	1.6 min (SIRTF)
Pointing stability	2 min	2 sec (SIRTF)
Data rates	1 Mbps	12 Mbps (OVLBI)
Power	200 W	500 W (OVLBI)
Mass	400 kg	6515 kg (SIRTF)
Revisit interval	Not crit.	6 months (SIRTF)
Real-time ops?	Some for target acquisition and verifying operation	
Major susceptibilities	RF in band	Heat sources within 60 degrees of FOV, water, carbon dioxide, and particles (SIRTF)
Thermal	200 W	500 W (OVLBI)
Manned services required/desired?	None	Small repairs

III X-ray astronomy

	Typical	Limiting
Preferred orbital inclination	0.0 (28.5 acceptible)	
Pointing direction	Celestial	Celestial
Pointing accuracy	3 min (LAMAR)	
Pointing stability	10 sec (LAMAR)	
Data rates	125 kbps (LAMAR)	
Power	2 kW (LAMAR)	
Mass	9289 kg (LAMAR)	
Revisit interval	3 years (LAMAR)	
Real-time ops?	Monitor	Monitor
Major susceptibilities	None identified	
Thermal	Passive	
Manned services required/desired?	None	Small repairs

IV Gamma-ray astronomy

	Typical	Limiting
Preferred orbital inclination	0.0 (28.5 acceptible)	
Pointing direction	Celestial	Celestial
Pointing accuracy	6 min (HRS)	
Pointing stability	36 sec (HRS)	
Data rates	30 kbps (HRS)	
Power	200 W	
Mass	500 kg (HRS)	
Revisit interval	6 months (HRS)	
Real-time ops?	Monitor (HRS)	
Major susceptibilities	Radiation	
Thermal	Passive	
Manned services required/desired?	None	Small repairs

V Cosmic-ray astrophysics

	Typical	Limiting
Preferred orbital inclination	57.0	90.0
Pointing direction	Anti-earth	
Pointing accuracy	Not critical	
Pointing stability	Not critical	
Data rates	100 kbps	102 kbps (SCRN)
Power	330 W	550 W (TRIC)
Mass	2826 kg	5750 kg (TRIC)
Revisit interval	6 months	
Real-time ops?	Monitor	
Major susceptibilities	None identified	
Thermal	Passive	
Manned services required/desired?	None	

VI Solar physics

	Typical	Limiting
Preferred orbital inclination	28.5	99.0 (SIDM)
Pointing direction	Solar	
Pointing accuracy	20 sec	10 sec (SCDM)
Pointing stability	2 sec	0.1 sec (SOT)
Data rates	650 kbps	42 Mbps (ASO)
Power	200 W	6 kW (ASO)
Mass	500 kg	11,000 kg (ASO)
Revisit interval	6 months	
Real-time ops?	Yes	Yes
Major susceptibilities	Hydrocarbons and particles	
Thermal	Passive	
Manned services required/desired?	None	Interactive ops

SUMMARY

ASTROPHYSICS REQUIREMENTS FOR A SPACE STATION

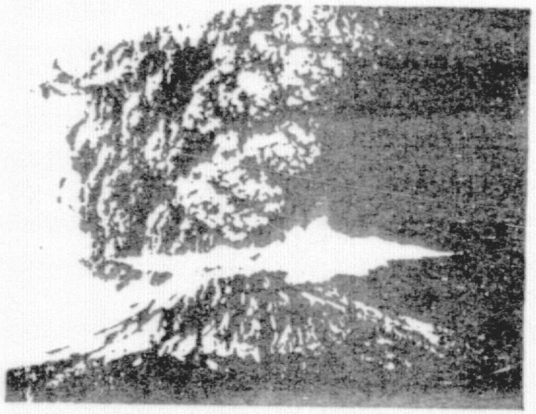
- Service our major observatories
- Assemble our large observatories
- Flexible, new tool for Astrophysics investigations
  1. Attach investigations that can tolerate disturbance
  2. Attach less tolerant investigations

CONCERNS

- Pointing stability
- Long duty cycle
- Contamination

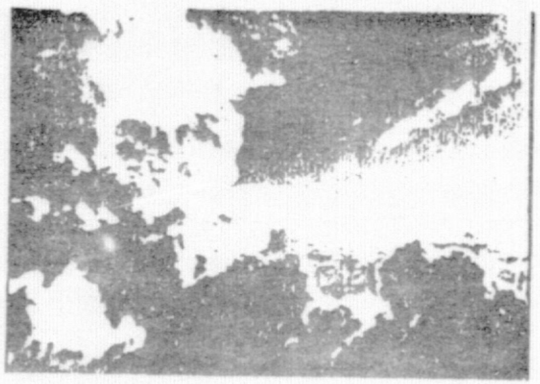
2-06

ENVIRONMENTAL OBSERVATIONS PROGRAM

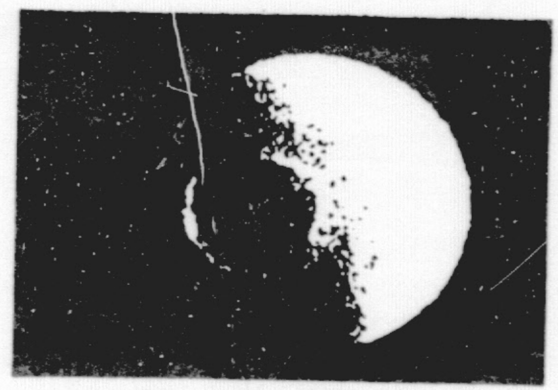


ATMOSPHERIC COMPOSITION

OCEANOGRAPHY



WEATHER & SEVERE STORMS



SPACE PLASMAS

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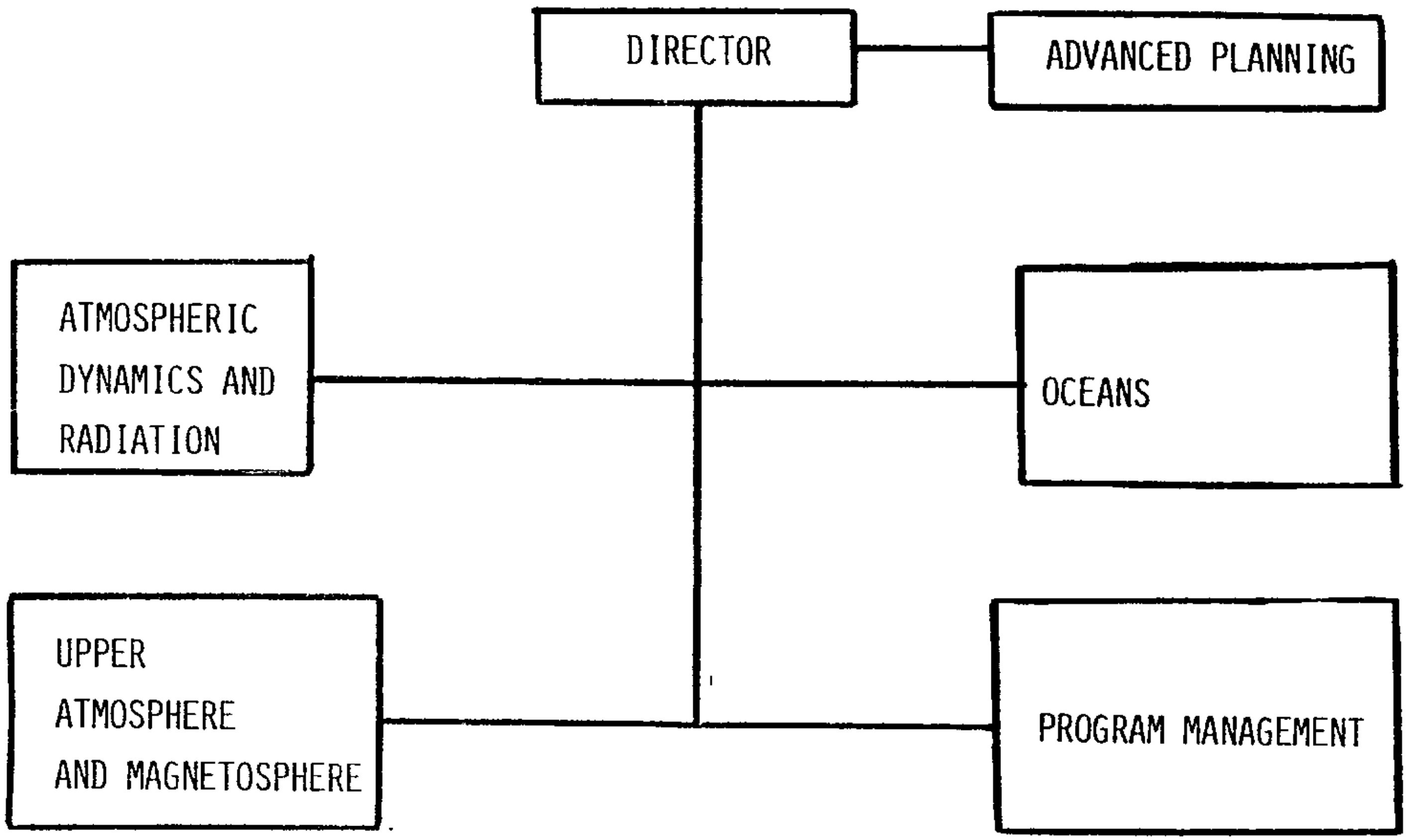
ENVIRONMENTAL OBSERVATION DIVISION



ENVIRONMENTAL OBSERVATIONS DIVISION
KEY PERSONNEL

DIRECTOR	DR. S. G. TILFORD	755-8620
ADVANCED PLANNER	DR. DIXON M. BUTLER	755-8604
OCEANS CHIEF	DR. W. STANLEY WILSON	755-8576
AIR-SEA INTERACTION	DR. L. F. MCGOLDRICK	755-8576
OCEAN OPTICS	DR. KENDALL L. CARDER	755-8576
GLOBAL WEATHER	MR. JOHN S. THEON	755-8596
CLIMATE	DR. ROBERT A. SCHIFFER	755-8596
SEVERE STORMS	DR. JAMES C. DODGE	755-8596
SPACE PLASMA PHYSICS	DR. E. R. SCHMERLING	755-8573
SPACE PLASMA PHYSICS	DR. MICHAEL J. WISKERCHEN	755-8673
SPACE PLASMA PHYSICS	DR. JOHN T. LYNCH	755-8576
AIR QUALITY	DR. ROBERT J. MCNEAL	755-8566
UPPER ATMOSPHERE	DR. ROBERT T. WATSON	755-8566
OPER. MET. SATS./OSIP	MR. RAY J. ARNOLD	755-8617
UARS	MR. DOUGLAS R. BROOME	755-8576
ERBE/HALOE	MR. RICHARD S. DILLER	755-8617
S/L P/L AND EXT'D ON'S	MR. GEORGE F. ESENWEIN	755-8617
TOPEX OCEANS STUDIES	MR. WILLIAM F. TOWNSEND	755-8576

ENVIRONMENTAL OBSERVATIONS PROGRAM

UNDERSTAND THE FLOW OF ENERGY FROM THE SUN THROUGH THE ENVIRONMENT

- SOLAR OUTPUT
- SUN-EARTH INTERACTIONS
- CIRCULATION OF THE ATMOSPHERE AND OCEANS
- COUPLING OF THE GLOBAL ENVIRONMENTAL SYSTEM

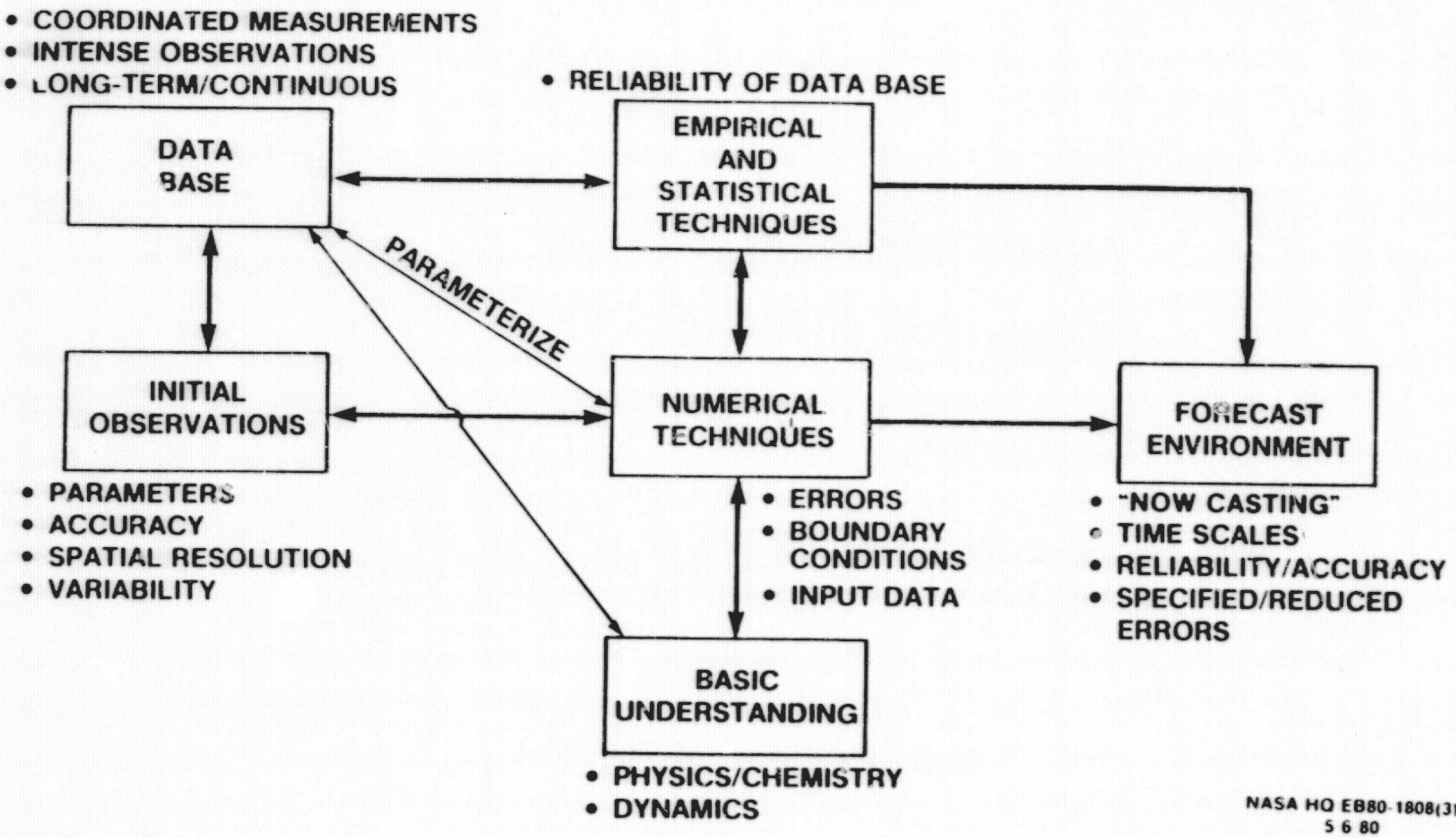
DETERMINE MAN'S ROLE IN THE ENVIRONMENT

- ATMOSPHERIC COMPOSITION
- OCEAN PRODUCTIVITY
- CLIMATE CHANGE

MAKE FORECASTS AND ASSESSMENTS

- OZONE DEPLETION
- CLIMATE FORECASTS
- OCEAN CHANGES
- WEATHER AND SEVERE STORMS
- SOLAR VARIABILITY

FOR ANY PROBLEM: THE PROCESS



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SPACE PLASMA PHYSICS PROGRAM

OBJECTIVES

TO UNDERSTAND SPACE PLASMAS AND THE COMPLEX INTERACTIVE PROCESSES THAT COUPLE THE EARTH AND SUN IN WHICH PLASMAS PLAY A SIGNIFICANT ROLE.

MEANS

MAIN THRUSTS	SYSTEM STUDIES (MULTI-SPACECRAFT) ACTIVE EXPERIMENTS (SPACELAB)
ROCKETS	VERTICAL PROFILES LOW ALTITUDES SPECIAL STUDIES
BALLOONS	ELECTRIC FIELDS
DATA ANALYSIS	
SUPPORTING RESEARCH AND TECHNOLOGY	CONCEPT STUDIES THEORY MODELLING INSTRUMENT DEVELOPMENT

ORIGIN OF PLASMAS IN EARTH'S NEIGHBORHOOD (OPEN)
STATUS

OBJECTIVE: ASSESS THE FLOW OF ENERGY AND MATTER THROUGH THE SOLAR WIND-MAGNETOSPHERE-IONOSPHERE SYSTEM

RECOMMENDED BY: INT'L MAGNETOSPHERIC STUDY STEERING COMMITTEE JULY 1979
NATIONAL ACADEMY COMM. ON SOLAR AND SPACE PHYSICS JAN 1980

AO STATUS: RELEASED OCT 1979
SELECTION FOR DEFINITION PHASE DECEMBER 1981

STUDY STATUS: CONCEPT STUDIES STARTED 1978
PHASE B INSTRUMENT STUDIES UNDERWAY
EXTENDED PHASE A SPACECRAFT STUDY

START: 1986

LAUNCH: 1990

CENTER: GODDARD SPACE FLIGHT CENTER

CONFIGURATION: 4 SPACECRAFT IN UNIQUE ORBITS WITH DIFFERING INSTRUMENT SETS

ATMOSPHERIC CHEMISTRY
PROGRAM ELEMENTS

LABORATORY MEASUREMENTS

- DESIGN PARAMETERS FOR MEASUREMENT TECHNIQUES
- REACTION MECHANISMS AND RATES FOR MODELS

GROUND, AIRCRAFT, BALLOON, ROCKET EXPERIMENTS

- PROCESS DETERMINATION
- GROUND TRUTH
- REMOTE SENSOR TECHNOLOGY DEVELOPMENT

SATELLITES

- GLOBAL CHEMICAL CLIMATOLOGY AND MORPHOLOGY
- LARGE SCALE PROCESS DETERMINATION
- UNIFIED DATA SET

NUMERICAL MODELING

- GUIDE FOR MEASUREMENT DESIGN AND STRATEGY
- QUANTIFY UNDERSTANDING AND INTERPRET RESULTS
- ENVIRONMENTAL IMPACT ASSESSMENT AND PREDICTION

UPPER ATMOSPHERE RESEARCH SATELLITE (UARS)
STATUS

OBJECTIVE:	OBTAIN INTEGRATED GLOBAL MEASUREMENTS OF UPPER ATMOSPHERE COMPOSITION, DYNAMICS, AND ENERGY INPUT
RECOMMENDED BY:	SPACE SCIENCE BOARD COMMITTEE ON SOLAR TERRESTRIAL RELATIONSHIPS
STUDY PHASE:	SCIENTIFIC WORKING GROUP OCTOBER 1977 - JULY 1978
AO RELEASED:	SEPTEMBER 15, 1978
PRELIMINARY SELECTION:	APRIL 1980 (16 EXPERIMENTAL & 10 THEORETICAL INVESTIGATIONS)
PHASE B INSTRUMENT STUDIES:	MAY 1980 - NOVEMBER 1981
FINAL SELECTION:	NOVEMBER 1981 (9 EXPERIMENTAL & 10 THEORETICAL INVESTIGATIONS)
START:	EXPERIMENTS AND MISSION STUDIES: FY 1982 SPACECRAFT AND GROUND SEGMENTS: FY 1984 CANDIDATE
LAUNCH:	FALL 1988
CENTER:	GODDARD SPACE FLIGHT CENTER
CONFIGURATION:	ONE SPACECRAFT IN 600 KM, 57° ORBIT, 18 MONTH LIFETIME

ORBITAL LIDAR FACILITY

OBJECTIVE: TEST LASER REMOTE SENSING CONCEPTS USING AN EVOLUTIONARY FACILITY CARRIED ON SHUTTLE

USES: REMOTE TROPOSPHERIC COMPOSITION MEASUREMENTS
HIGH VERTICAL RESOLUTION
INCREASED SENSITIVITY IN ATMOSPHERIC SOUNDING GENERALLY

STUDY PHASE: PHASE A STUDY COMPLETED IN 1980

START: 1987 NEW START CANDIDATE

WEATHER AND SEVERE STORMS PROGRAM ELEMENTS

SATELLITES

- INITIAL CONDITIONS FOR MODELS
- OBSERVE ATMOSPHERIC PROCESSES
- SEVERE STORM TRACKING FOR WARNINGS

FIELD EXPERIMENTS

- DETERMINE SMALL SCALE PROCESSES
- GROUND TRUTH
- GUIDE REMOTE SENSOR TECHNOLOGY DEVELOPMENT

NUMERICAL MODELING

- WEATHER PREDICTION AND STORM WARNINGS
- ASSESSMENT OF NEW OBSERVATION TECHNIQUES
- QUANTIFY UNDERSTANDING

NASA HQ E881-1871

WINDSAT

OBJECTIVE: MEASURE WIND VECTOR PROFILES USING DOPPLER LIDAR

MEASUREMENT NEEDS: GLOBAL COVERAGE FOR ONE YEAR PLUS
1 KM VERTICAL RESOLUTION TO >15 KM ALTITUDE
1 M/S ACCURACY IN WIND SPEED

STUDY PHASE: NASA AND NOAA FEASIBILITY STUDIES COMPLETED 1982

START: 1988 NEW START

NASA OCEAN PROGRAM

OCEAN CIRCULATION — TOPEX—DEDICATED ALTIMETER MISSION

— SCATTEROMETER PIGGYBACK ON US TOPEX, CANADA RADARSAT

OCEAN PRODUCTIVITY — OCEAN COLOR IMAGER—PIGGYBACK ON NOAA H

POLAR OCEANS — DATA FROM USAF DMSP MICROWAVE RADIOMETER

— ALASKA GROUND STATION FOR SAR ABOARD ESA ERS-1, JAPAN ERS-1, AND/OR RADARSAT

NASA HQ 82-917 (1)
4/20/82

OCEAN COLOR IMAGER (OCI)

OBJECTIVE: MEASURE GLOBAL OCEANIC CHLOROPHYLL IN ORDER TO UNDERSTAND OCEAN PRIMARY PRODUCTIVITY

RECOMMENDED BY: OCEAN SCIENCE BOARD (1982)

STUDY STATUS: SCIENCE REQUIREMENTS AND ACCOMODATION STUDIES VIRTUALLY COMPLETE

NOAA INTERESTED IN JOINT EFFORT

START: 1984 NEW START CANDIDATE - NEEDED TO MEET SCHEDULE

LAUNCH: PIGGYBACK FLIGHT OPPORTUNITY ABOARD NOAA-H

CENTER: GODDARD SPACE FLIGHT CENTER

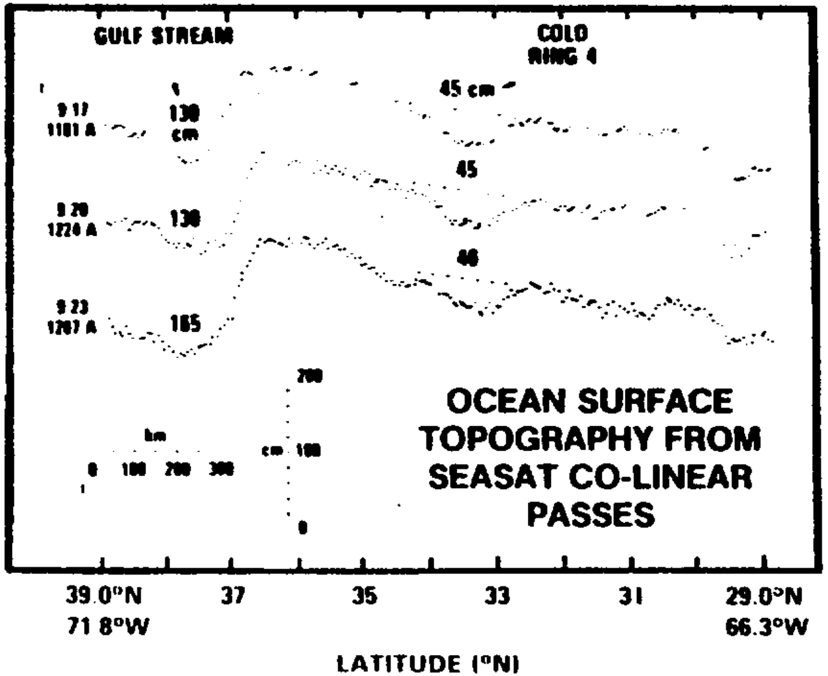
CONFIGURATION: MIRROR SCAN, 6 CHANNEL, VISIBLE AND NEAR VISIBLE RADIOMETER

- SURFACE CURRENTS OBTAINED FROM MEASUREMENT OF ELEVATION OF SEA SURFACE

- RELATE REDISTRIBUTION OF HEAT BY GLOBAL CURRENTS TO CLIMATE

- BENEFIT IN LOCATING FRONTS AND EDDIES FOR NAVY

- A DEDICATED MISSION IS REQUIRED



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NASA HQ82 936 (3)
4 30 82

TOPOGRAPHY EXPERIMENT (TOPEX)

STATUS

OBJECTIVE: TO ADVANCE OUR UNDERSTANDING OF GLOBAL OCEANIC CIRCULATION

RECOMMENDED BY:

- NATIONAL ADADEMY OF SCIENCES (SPACE SCIENCE BOARD/COMMITTEE ON EARTH SCIENCES; OCEAN SCIENCE BOARD; CLIMATE BOARD; COMMITTEE ON GEODESY) (1982)
- NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE (1981)
- COMMITTEE FOR CLIMATE CHANGE IN THE OCEAN (1982)
- JOINT SCIENTIFIC COMMITTEE (1982)

STUDY STATUS:

- SCIENCE REQUIREMENTS DEFINED 1981
- PHASE A COMPLETED 1981
- LOW COST APPROACH UNDER STUDY
- BREADBOARDING OF HIGH TECHNOLOGY ITEMS IN PROGRESS

START: 1985 NEW START CANDIDATE

LAUNCH: 1988

CENTER: JET PROPULSION LABORATORY

CONFIGURATION: DEDICATED ALTIMETER MISSION FOR 3 YEARS IN 1300 KM, 65° ORBIT WITH PRECISELY REPEATING GROUND TRACKS EVERY 10 DAYS

WIND SCATTEROMETER (SCATT)

STATUS

OBJECTIVE: PROVIDE GLOBAL MEASUREMENTS OF OCEAN SURFACE WINDS, AND TO UNDERSTAND THE WIND DRIVEN COMPONENT OF THE OCEAN CIRCULATION

RECOMMENDED BY:

- NATIONAL ACADEMY OF SCIENCES (SPACE SCIENCE BOARD/COMMITTEE ON EARTH SCIENCES; OCEAN SCIENCES BOARD; CLIMATE BOARD) (1982)
- NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE (1981)
- COMMITTEE FOR CLIMATE CHANGE IN THE OCEAN (1982)
- JOINT SCIENTIFIC COMMITTEE (1982)

STUDY STATUS: SCIENCE REQUIREMENTS DEFINED - 1982
FEASIBILITY ASSESSMENT OF FLYING PIGGYBACK ON TOPEX UNDERWAY

START: 1985 NEW START CANDIDATE

LAUNCH: PIGGYBACK POSSIBLE ON: NAVY ROSS, TOPEX, CANADIAN RADARSAT

CENTER: TBD

CONFIGURATION: 6 STICK Ku BAND INSTRUMENT WITH RAIN DETECTION RADIOMETER

FREE FLYING IMAGING RADAR EXPERIMENT (FIREX)

STATUS

OBJECTIVE: USE A SYNTHETIC APERTURE RADAR PRIMARY SENSOR TO CHARACTERIZE ICE, OCEAN AND LAND FEATURES

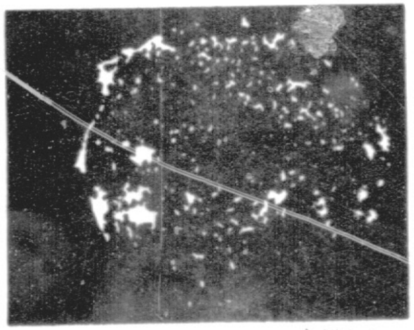
STUDY STATUS: MISSION REQUIREMENTS DEFINED - 1982
POSSIBLE COOPERATION WITH CANADA'S RADARSAT

START: 1987 NEW START CANDIDATE

CENTER: JET PROPULSION LABORATORY

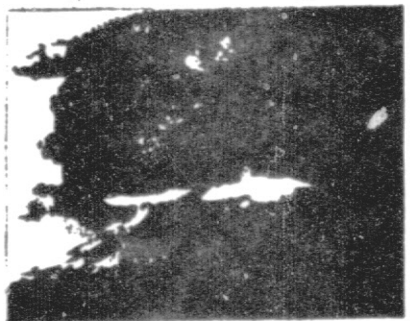
CONFIGURATION: POLAR ORBIT WITH 150 KM+ SWATH WIDTH, 25 M RESOLUTION, AND GLOBAL COVERAGE EVERY 3 DAYS

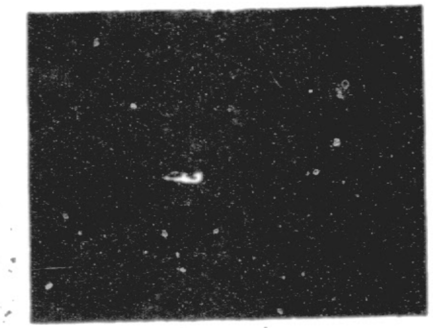
CLIMATE LONG TERM MEASUREMENT NEEDS



SOLAR OUTPUT

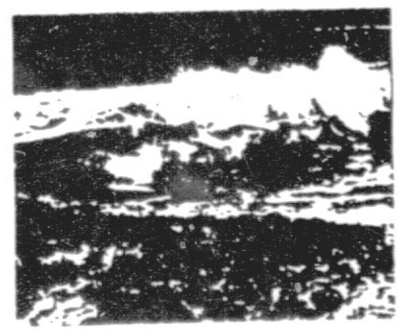
EARTH RADIATION BUDGET





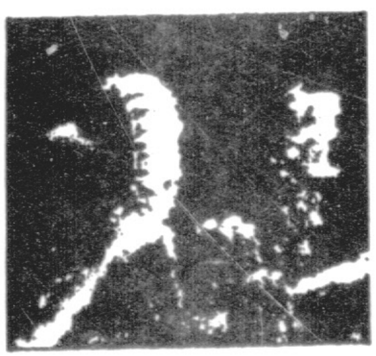
AEROSOLS

CLOUDS



ATMOSPHERIC COMPOSITION

OCEAN HEAT TRANSPORT



SNOW/ICE COVER

PRECIPITATION

NASA HQ E881-1096
6-4-81

ENVIRONMENTAL OBSERVATIONS PROGRAM

CORE EFFORT

- RESEARCH, DATA ANALYSIS, TECHNIQUE DEVELOPMENT

APPROVED MISSIONS IN DEVELOPMENT

- AMPTE, ERBE

MAJOR PROPOSED MISSIONS

- UARS, OCI
  - TOPEX, SCATT
    - OPEN
      - LIDAR
        - WINDSAT, FIREX

PROPOSED MODEST INITIATIVES

- SPACE LAB I, II AND VI
- GLOBAL TROPOSPHERE EXPERIMENT
- LIGHTNING MAPPER
- OCEAN DATA SYSTEM
- AIR-SEA INTERFACE SPECIAL STUDY
- SOLAR CONSTANT EXPLORER

CATEGORIES OF ENVIRONMENTAL OBSERVATION MISSIONS

SUN LOOKING

EARTH LOOKING

REMOTE SENSING

IN SITU OBSERVATIONS

ACTIVE EXPERIMENTS

REMOTE SENSING

OBJECTIVES:

GLOBAL COVERAGE
CONTINUOUS VIEWING - SHORT TIME PHENOMENA

TYPES:

PASSIVE
ACTIVE-LIDAR AND RADAR

EXAMPLE: UPPER ATMOSPHERE RESEARCH SATELLITE EXPERIMENTS (UARSE)

MEASUREMENTS: VISIBLE, INFRARED, ULTRAVIOLET AND MICROWAVE OBSERVATIONS OF THE EARTH'S LIMB, UV NADIR SOUNDING FOR OZONE, UV SOLAR AND STELLAR OBSERVATIONS

OBJECTIVES: UNDERSTAND THE COUPLING OF DYNAMICS, ENERGETICS AND COMPOSITION OF THE STRATOSPHERE

SPECIAL NEEDS: SIMULTANEOUS VIEWING OF NADIR, BOTH LIMBS, SUN, AND LIMB $\pm 45^{o}$ OF SATELLITE, MASSIVE PAYLOAD (>2000KG), SOLID HYDROGEN CRYOGEN (10^{o}K), GLOBAL COVERAGE AT LIMB

IMPACTS: ONE INSTRUMENT LIFETIME LIMITED (18 MONTHS), ORBITS OF ROUGHLY 70^{o} INCLINATION, SATELLITE SIZE

SOLUTION: UNIQUE FREE FLYER

EXAMPLE: OCEAN CIRCULATION TOPOGRAPHY EXPERIMENT (TOPEX)

MEASUREMENTS: SEA SURFACE HEIGHT TO 2 CM ACCURACY

OBJECTIVES: DETERMINE THE GLOBAL GEOSTROPHIC CIRCULATION OF THE OCEAN

SPECIAL NEEDS: PRECISION ORBIT DETERMINATION, COVERAGE OF GLOBAL OCEAN, AVOID TIDAL ALIASING

IMPACTS: ORBIT, SPACECRAFT DESIGN

SOLUTION: AERODYNAMICALLY CLEAN SPACECRAFT IN 63.4° 1384 KM ORBIT (UNIQUE)

EXAMPLE: LIGHTNING MAPPER

MEASUREMENTS: LOCATION AND STRENGTH OF LIGHTNING FLASHES

OBJECTIVES: DETERMINE THE ROLE OF LIGHTNING IN THE OVERALL ENVIRONMENTAL SYSTEM

SPECIAL NEEDS: CONTINUOUS VIEWING, DAY AND NIGHT SENSITIVITY

IMPACTS: ORBIT

SOLUTION: GEOSYNCHRONOUS (5 LOCATIONS)

EXAMPLE: HIGH RESOLUTION DOPPLER IMAGER (HRDI)

MEASUREMENTS:	DOPPLER SHIFT IN VISIBLE EMISSIONS ON THE LIMB
OBJECTIVES:	DIRECT MEASUREMENT OF MIDDLE ATMOSPHERE WINDS
SPECIAL NEEDS:	POINTING STABILITY AND KNOWLEDGE: $.03^{\circ}$ CONTROL, $.002^{\circ}/100$ SEC STABILITY, $.025^{\circ}$ YAW KNOWLEDGE
IMPACTS:	SPACECRAFT DESIGN AND OPERATIONS
SOLUTION:	STABLE PLATFORM

EXAMPLE: SPACELAB VI PAYLOAD

MEASUREMENTS:	INJECT WAVES AND ENERGETIC PARTICLES INTO SPACE PLASMAS
OBJECTIVES:	CONDUCT BASIC PLASMA PROCESS STUDIES AND ACTIVELY PROBE TO OBSERVE SPACE PLASMA ENVIRONMENT
SPECIAL NEEDS:	REAL-TIME CONTROL AND COORDINATION, HIGH POWER PULSES, FLEXIBLE CHOICE OF ORIENTATION, CO-ORBITING DETECTORS
IMPACTS:	MISSION DESIGN AND OPERATIONS
SOLUTION:	PRIMARY CONTROL OF LARGE PLATFORM WITH SUBSATELLITES

<u>EXAMPLE</u>: <u>OCEAN COLOR IMAGER (OCI)</u>

MEASUREMENTS: COLOR OF THE OCEAN

OBJECTIVE: DETERMINE PHYTOPLANKTON ABUNDANCE AND OCEAN BIOLOGICAL PRODUCTIVITY

SPECIAL NEEDS: SUN ANGLE MUST BE WITHIN $\pm 50^{0}$ OF NADIR, COVER GLOBAL OCEAN

IMPACTS: ORBIT AND/OR OPERATING TIMELINE

SOLUTION: FLY SUN-SYNCHRONOUS WITH HOUR ANGLES BETWEEN 10 A.M. AND 2 P.M.

EXAMPLE: FREE FLYING IMAGING RADAR EXPERIMENT (FIREX)

MEASUREMENT:	HIGH RESOLUTION (25M) MICROWAVE IMAGE
OBJECTIVES:	DETERMINE DYNAMICS OF SEA ICE, CHARACTERIZE STATE OF VEGETATION, MAP SURFICIAL GEOLOGICAL FEATURES
SPECIAL NEEDS:	GLOBAL COVERAGE, 120 MBPS DATA RATE, AXIS OF ANTENNA ALONG VELOCITY VECTOR, 6 KW POWER
IMPACTS:	ORBIT, OPERATING TIMELINE, STABILITY, SPACECRAFT DESIGN
SOLUTION:	POLAR ORBIT, ON BOARD PROCESSING OR TDRSS WORKAROUND, CONSTRAINED ORIENTATION

EXAMPLE: LIDAR

MEASUREMENT:	ATMOSPHERIC RESPONSE TO LASER RADIATION
OBJECTIVES:	SOUND FOR WINDS AND CHEMICAL COMPOSITION OF THE ATMOSPHERE
SPECIAL NEEDS:	>3.5 KW POWER, LONG LIFE LASER, CLEAN OPTICS, GLOBAL COVERAGE, >2000 KG
IMPACTS:	ORBIT, STRUCTURE, CONTAMINATION
SOLUTION:	POLAR ORBIT, LARGE SPACECRAFT

EXAMPLE: GEOSYNCHRONOUS MICROWAVE SOUNDING

MEASUREMENT: MICROWAVE EMISSIONS OF LAND, OCEAN, AND ATMOSPHERE

OBJECTIVES: ALL WEATHER TIME VARIATION OF ATMOSPHERIC TEMPERATURE STRUCTURE, MOISTURE, AND SURFACE TEMPERATURE

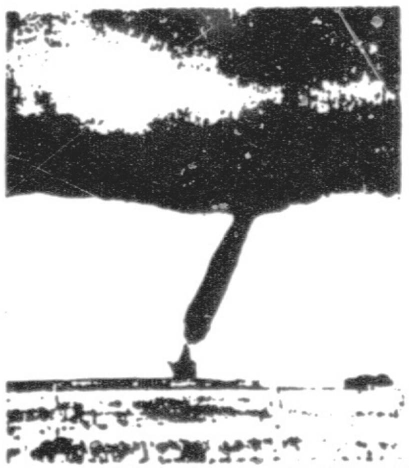
SPECIAL NEEDS: LARGE ANTENNA (>25M DIAMETER)

IMPACTS: STRUCTURE, ORBIT

SOLUTION: LARGE SPACECRAFT

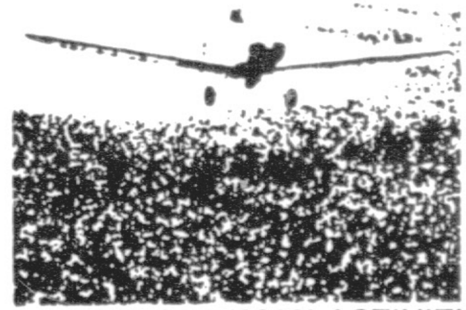
WEATHER AND SEVERE STORMS APPLICATIONS

STORM WARNINGS



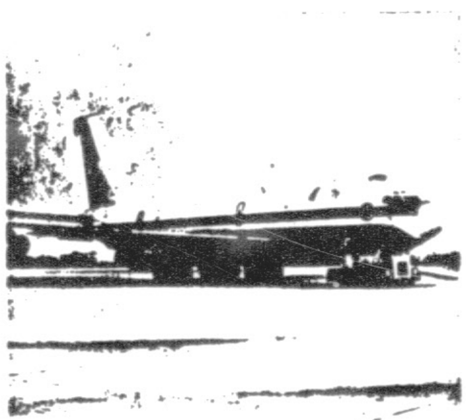
MINIMIZE LOSS OF LIFE AND PROPERTY DAMAGE

WEATHER FORECASTING



PLANNING HUMAN ACTIVITIES

ROUTING

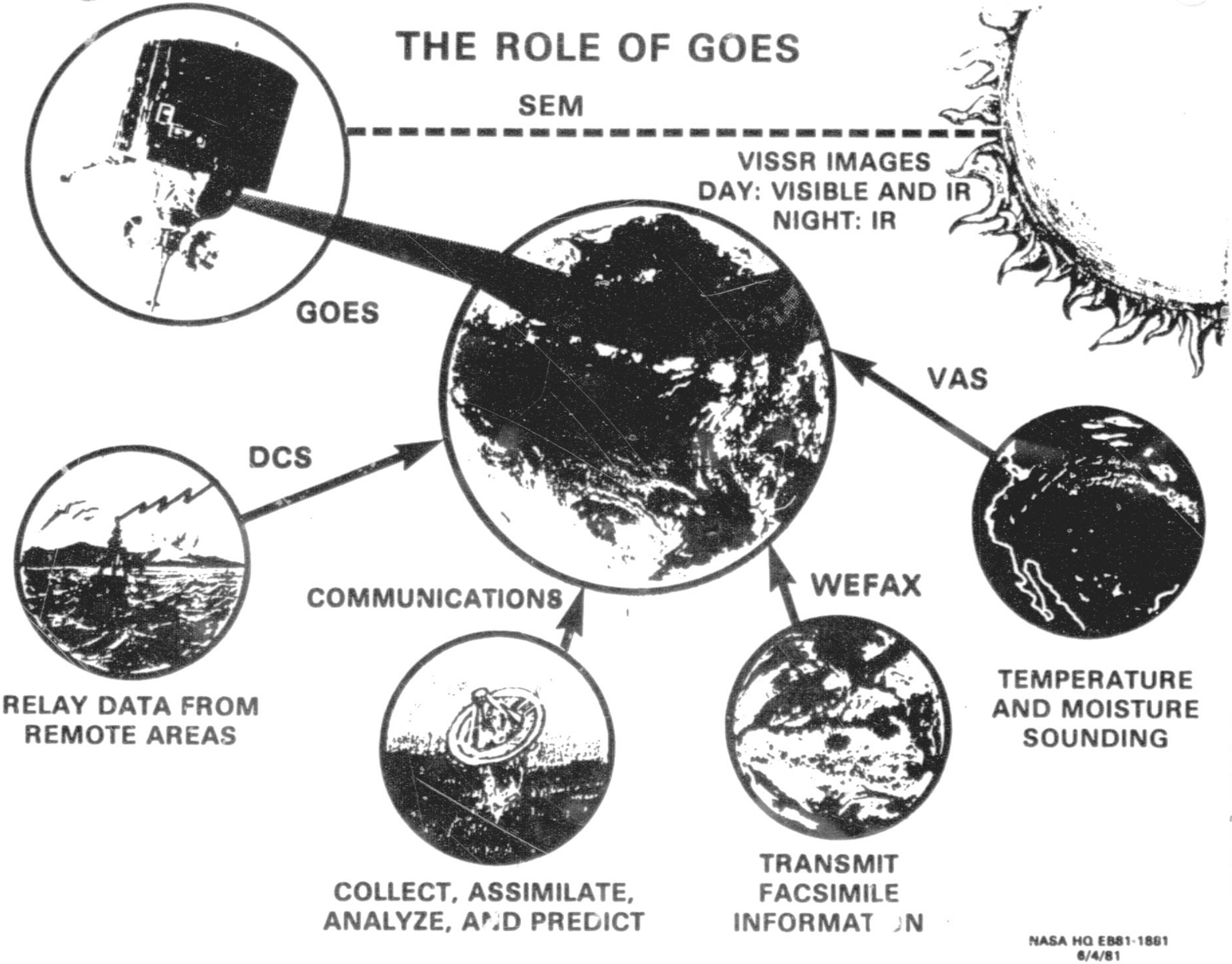


MANAGEMENT OF ENVIRONMENTALLY SENSITIVE OPERATIONS

EMERGENCY PREPAREDNESS

READINESS FOR FLOODS, BLIZZARDS ETC.

THE ROLE OF GOES



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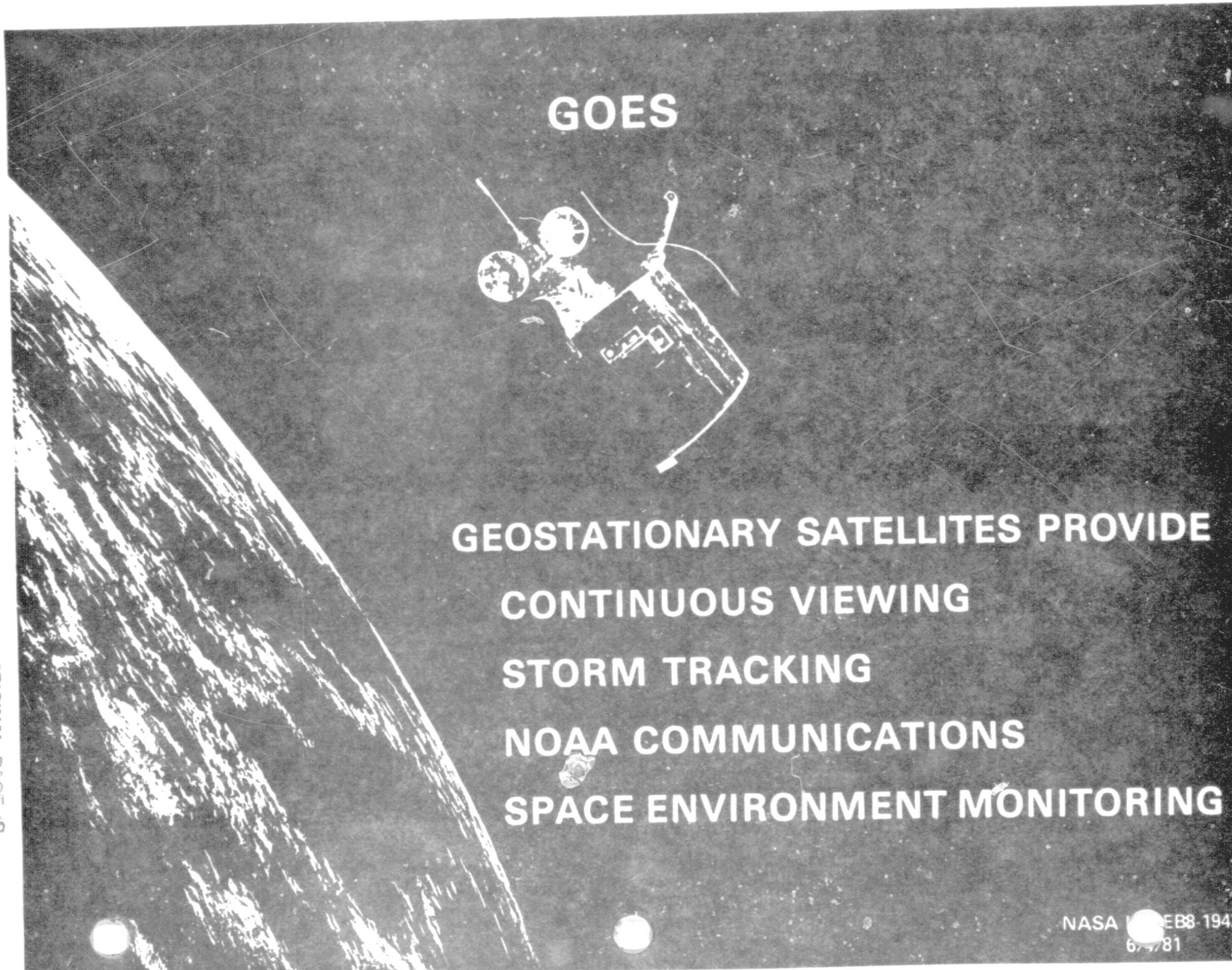
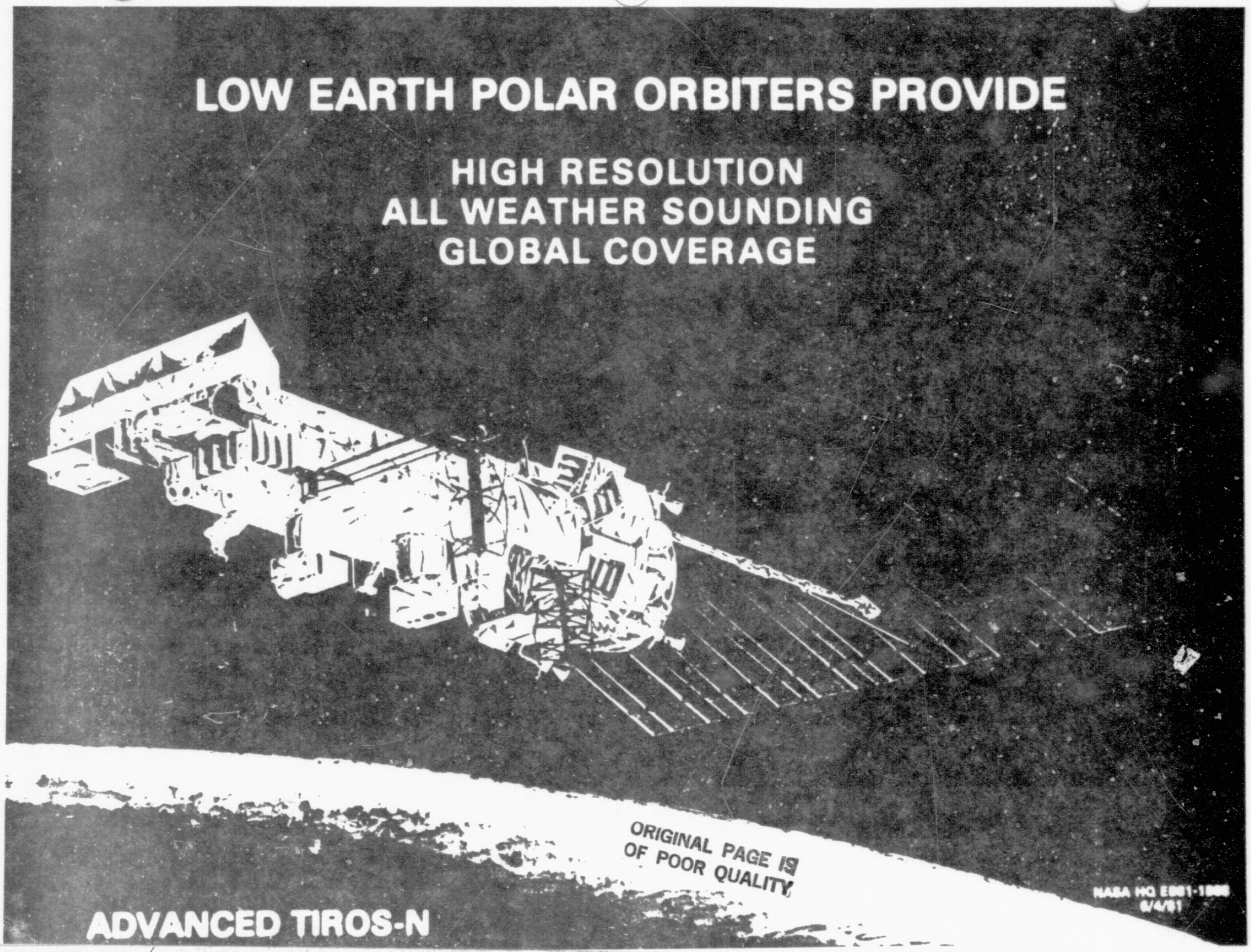

GOES
GEOSTATIONARY SATELLITES PROVIDE
CONTINUOUS VIEWING
STORM TRACKING
NOAA COMMUNICATIONS
SPACE ENVIRONMENT MONITORING
NASA

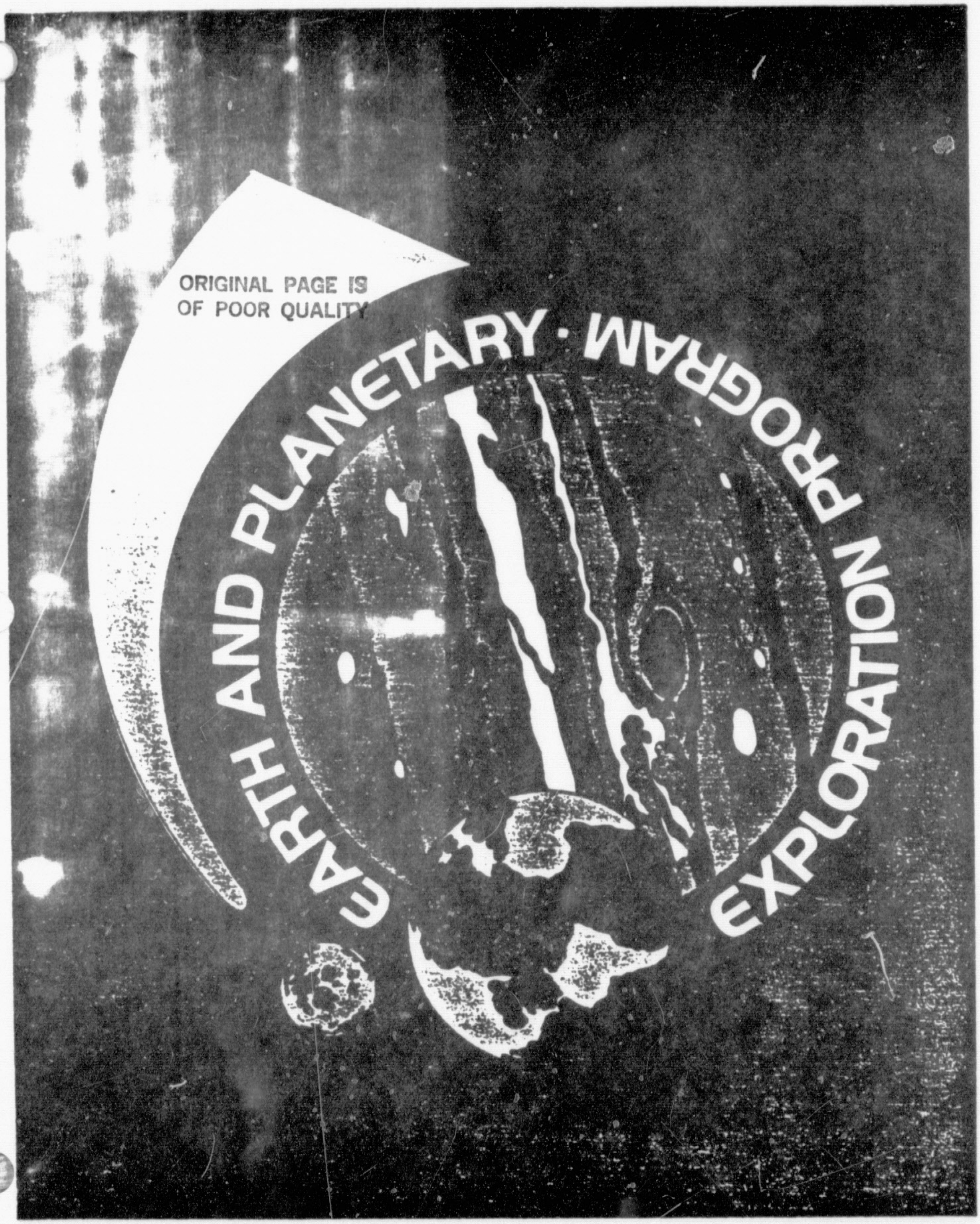

LOW EARTH POLAR ORBITERS PROVIDE
HIGH RESOLUTION
ALL WEATHER SOUNDING
GLOBAL COVERAGE
ADVANCED TIROS-N

NOAA SATELLITES INSTRUMENT PLAN

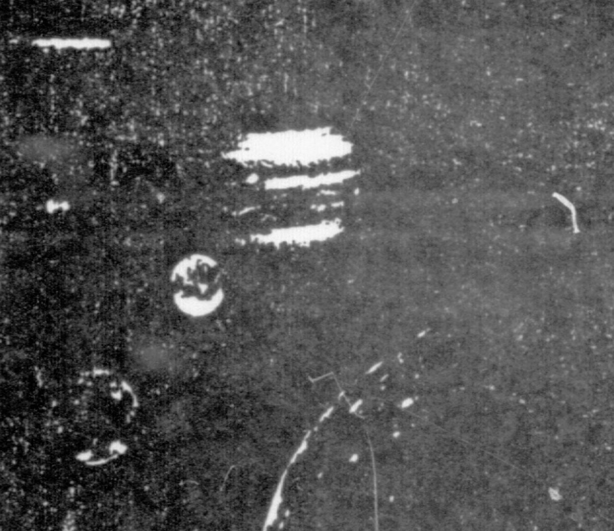
	LAUNCH DATE	AVHRR	HIRS-2	MSU	SSU	DCS	SBUV	ERBE	SEM	SAR
TIROS-N	10/78	●	●	●	○	●			●	
NOAA-A	6/79	●	●	●	○	●			●	
NOAA-C	6/81	●	●	●	○	●			●	
NOAA-D	10/81	●	●	●	☆	●			☆	
NOAA-E	5/83	●	●	●	○	●			●	●
NOAA-F	10/83	●	●	●	☆	●	○	○	*	●
NOAA-G	5/85	●	●	●	○	●	○	○	●	●
NOAA-H	10/85	●	●	●	☆	●	○	☆	☆	
NOAA-I	5/87	●	●	●	○	●	○	☆	●	
NOAA-J	10/87	●	●	●	☆	●	○	☆	☆	

☆ SPACE, WT, POWER UNASSIGNED

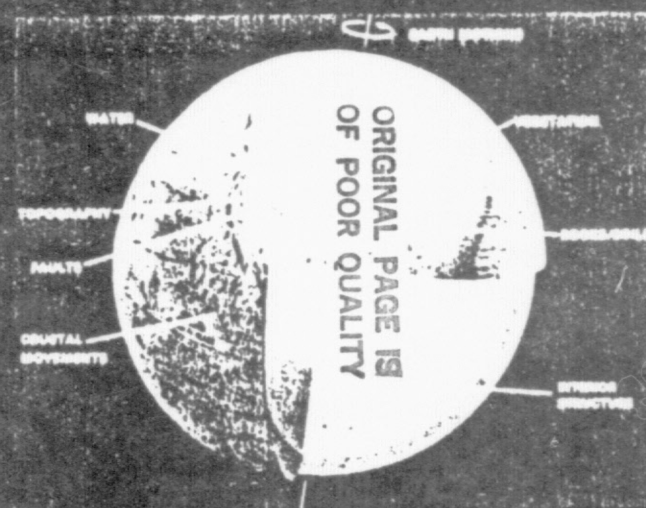
* POSSIBLE DOE NUCLEAR TESTING DEVELOPMENT DETECTOR IN PLACE OF SEM ON NOAA-F


EARTH AND PLANETARY · PROGRAM
EXPLORATION

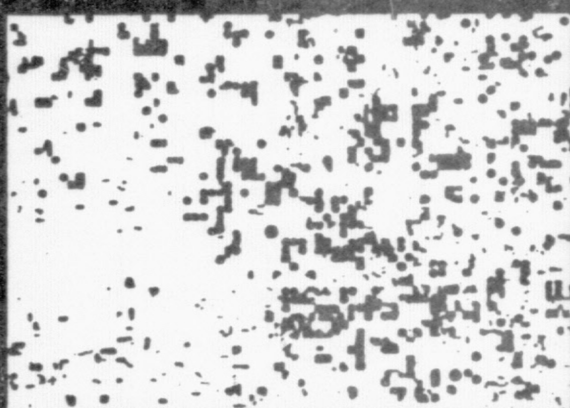
Earth and Planetary Exploration Goals



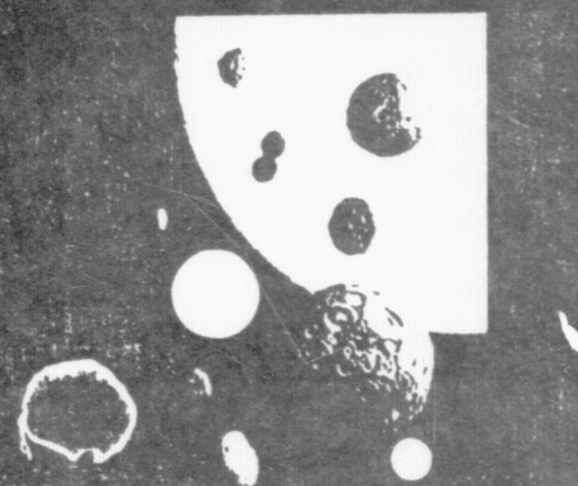
State of Solar System



Understand Earth as a Planet



Earth Resources Research



Survey of Near-Earth Space

Earth and Planetary Exploration

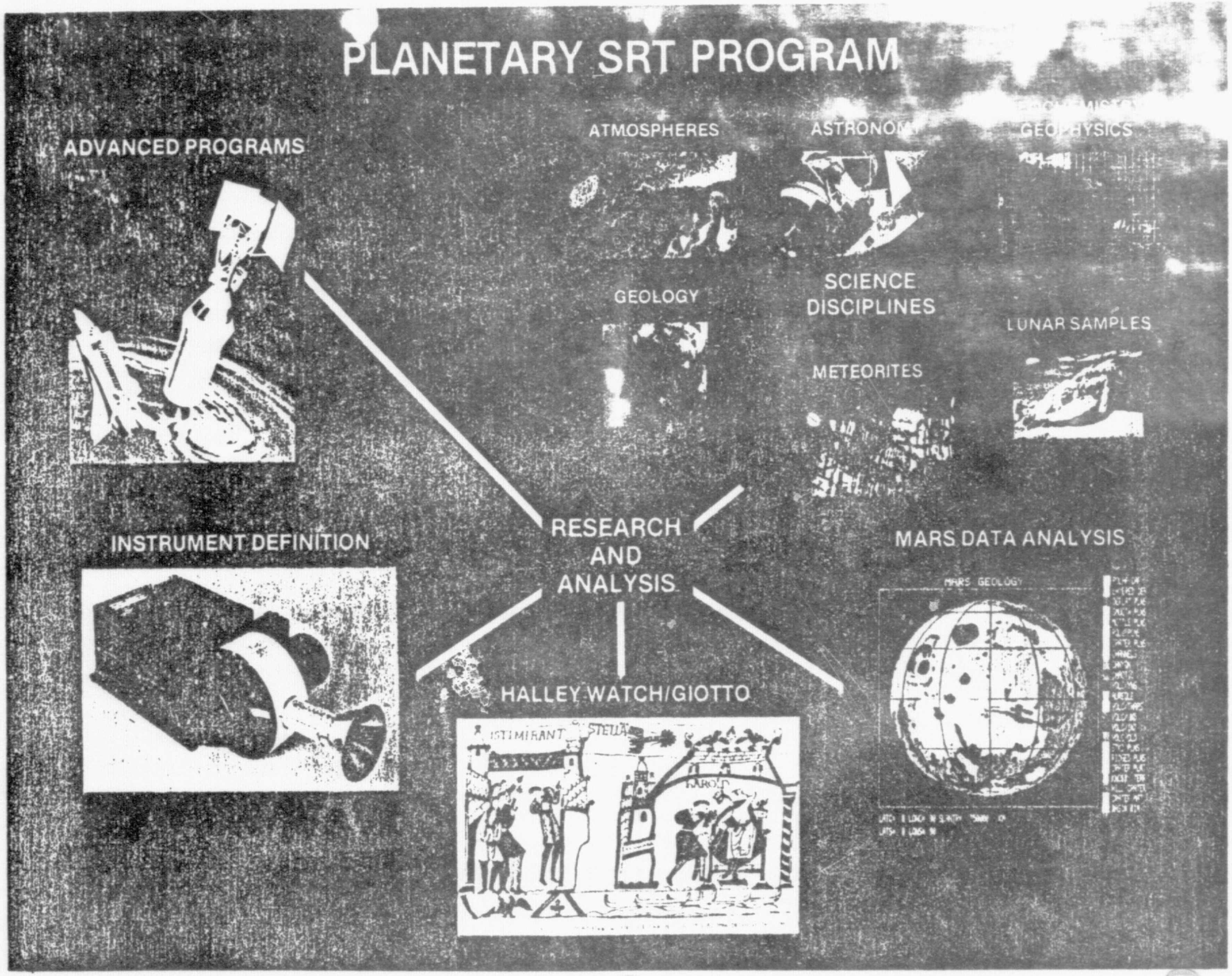
Strategy

- Establish and Maintain a Strong Research Program in Both Fundamental and Applied Science
  - Maintain a Strong Research Base at Scientific Institutions
  - Optimize Data Return from Operating Spacecraft
  - Conduct a Program of Earth and Planetary Flight Missions
  - Establish and Maintain a Payload Program which Capitalizes on the Benefits and Opportunities Afforded by the Space Transportation System
  - Establish Collaborative Programs with U.S. Government Agencies and International Research Groups

- Maintain U.S. Leadership in Remote Sensing R&D, Planetary Exploration, and Space Application to Geology and Geodynamics
  - Operate within Framework of U.S. Space Policy and Science Goals Derived by the National Academy of Science

- Establish and Maintain Synergism in Science/Technology Development Programs between Planetary and Earth Exploration

- Promote International, Interagency, State and Local Government, University, and Industry Involvement in Earth Resources Applications Programs


PLANETARY SRT PROGRAM
ADVANCED PROGRAMS
ATMOSPHERES
GEOLOGY
SCIENCE DISCIPLINES
METEORITES
LUNAR SAMPLES
RESEARCH AND ANALYSIS
INSTRUMENT DEFINITION
HALLEY WATCH/GIOTTO
MARS DATA ANALYSIS
MARS GEOLOGY

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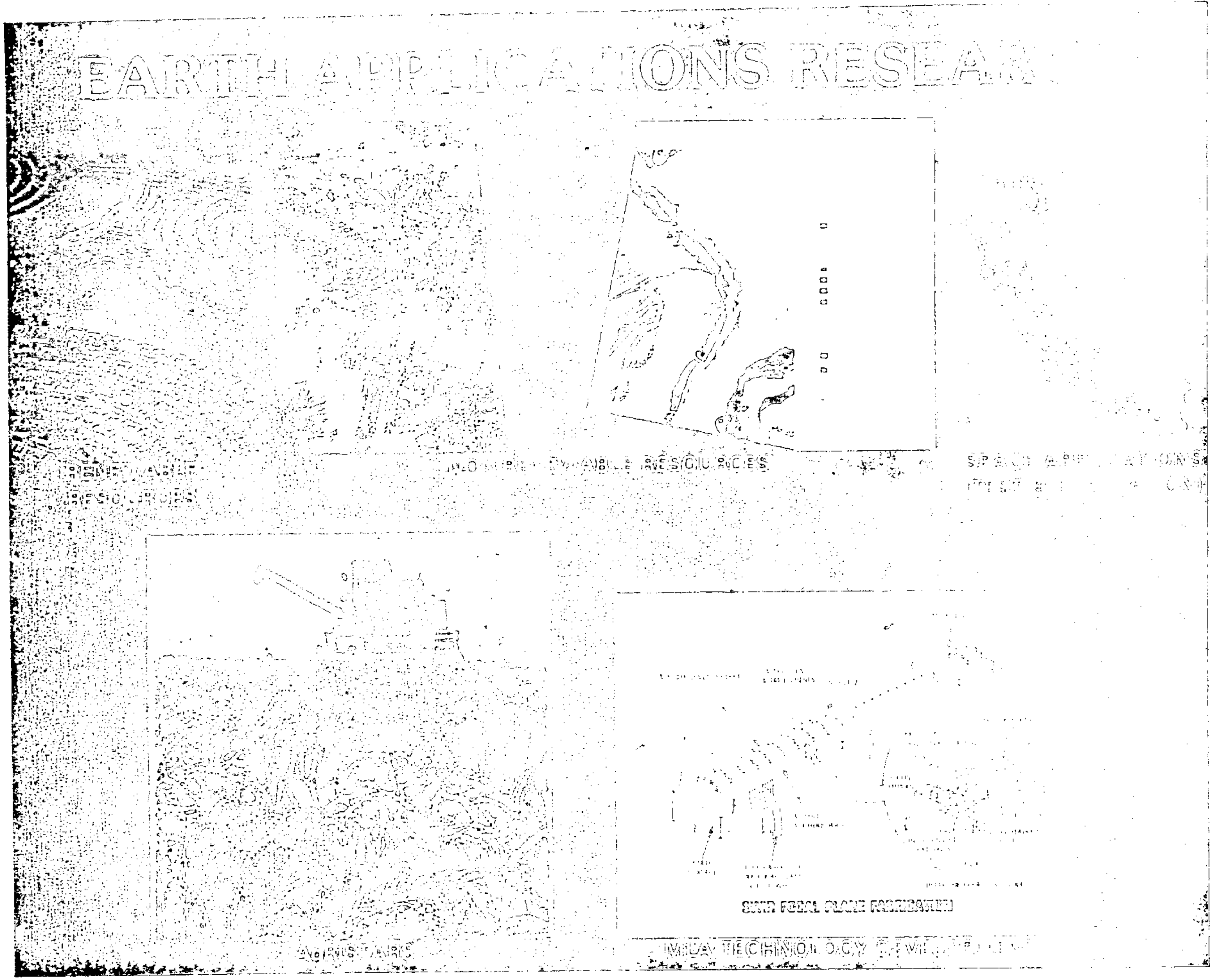
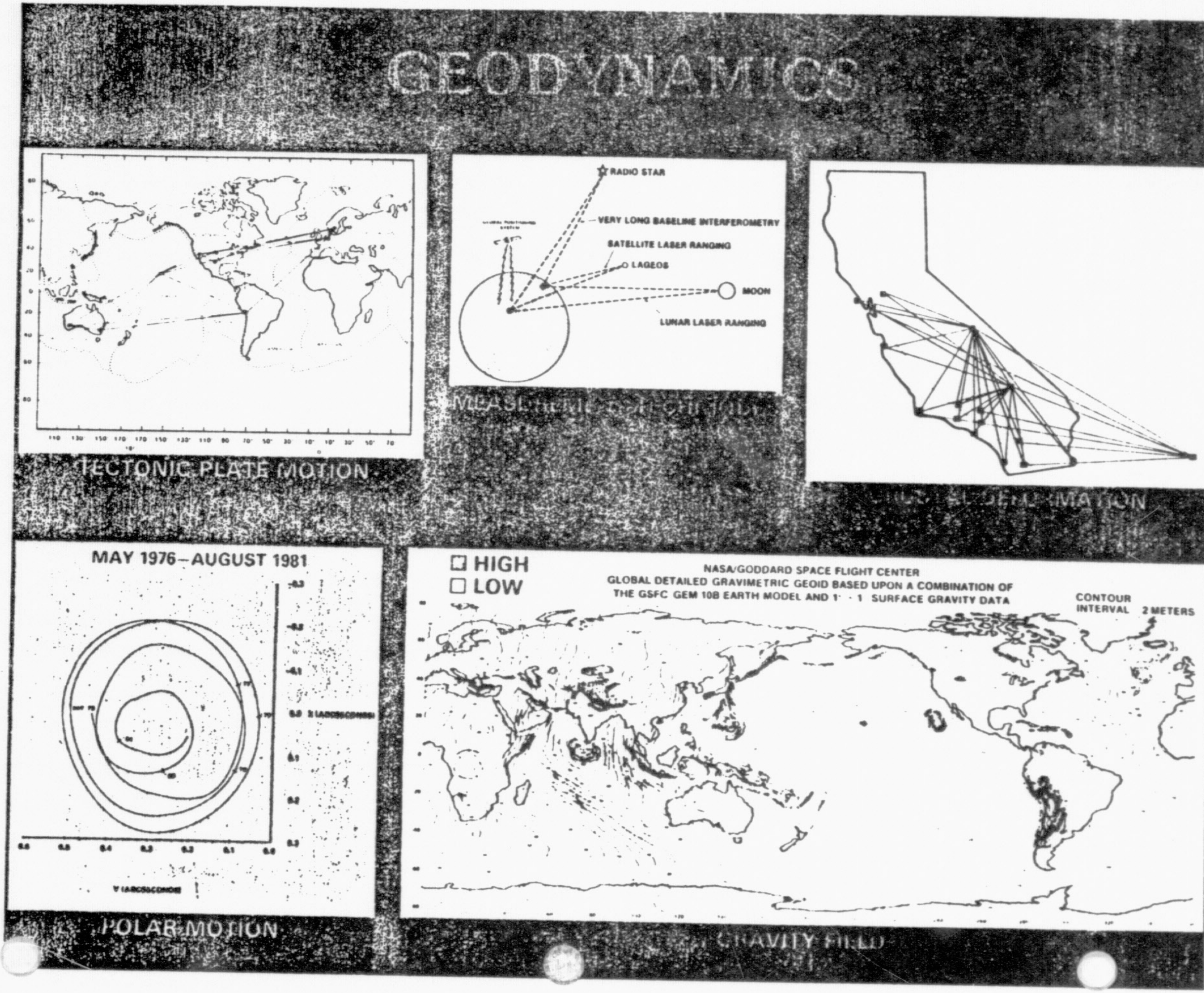
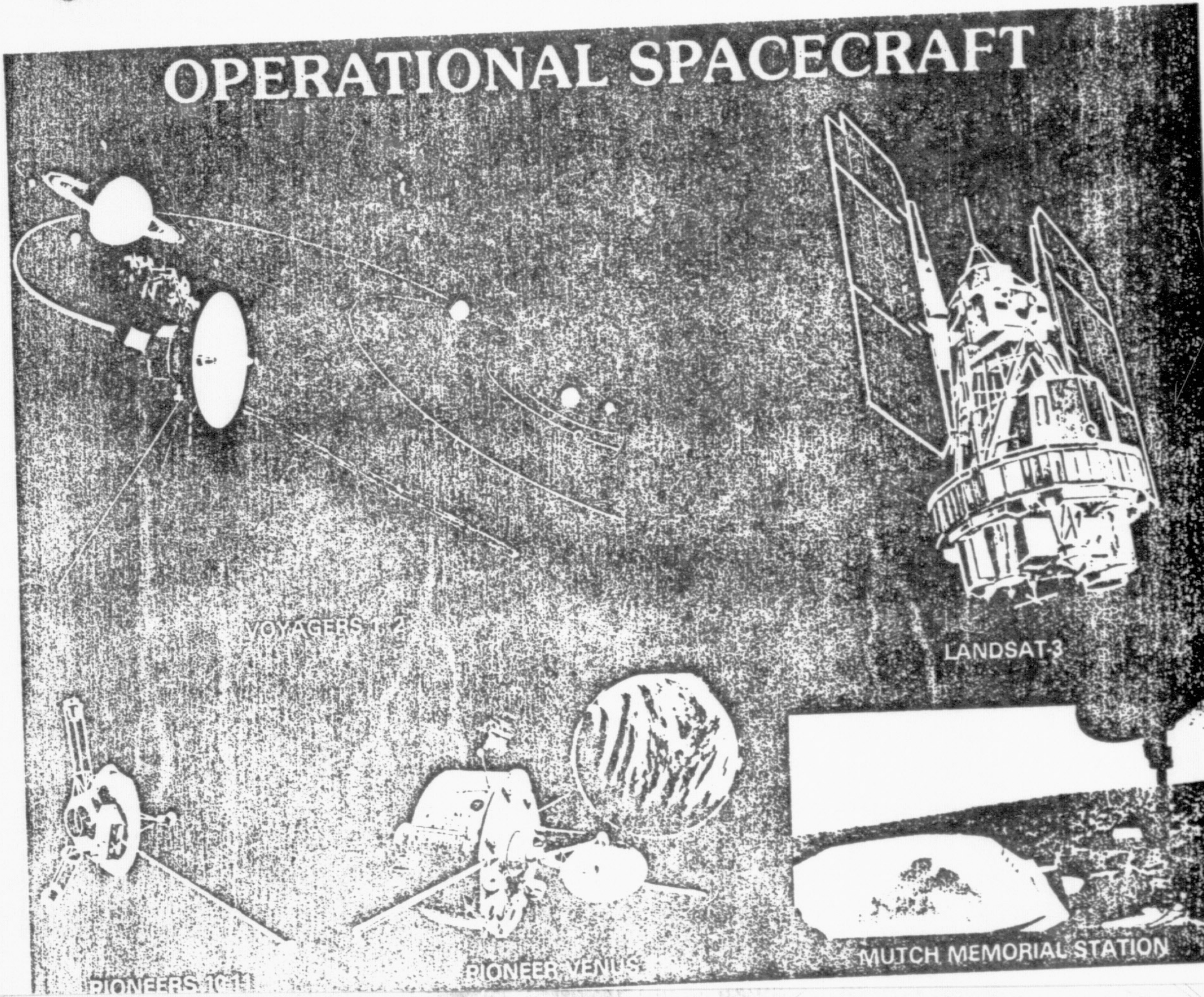
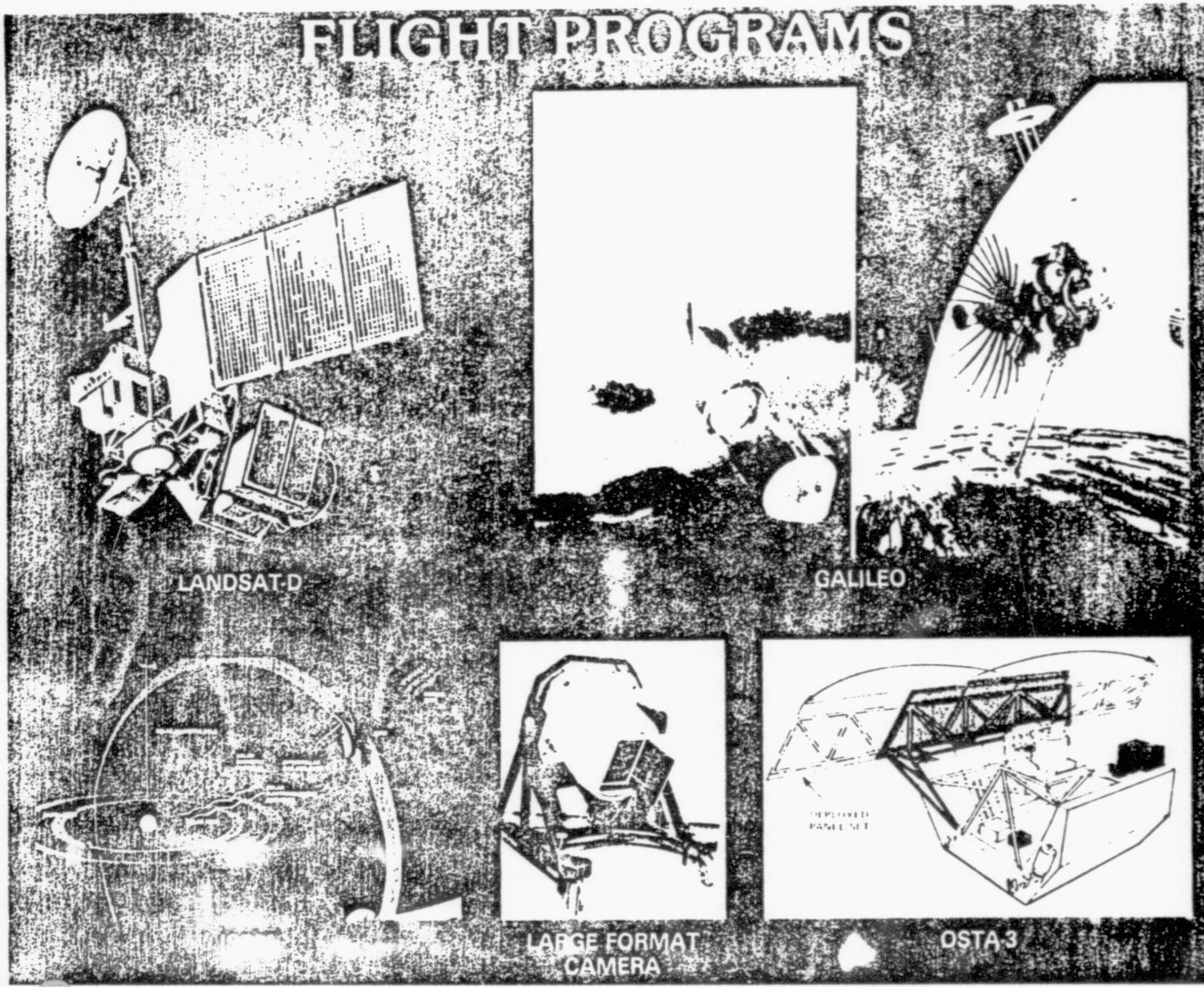


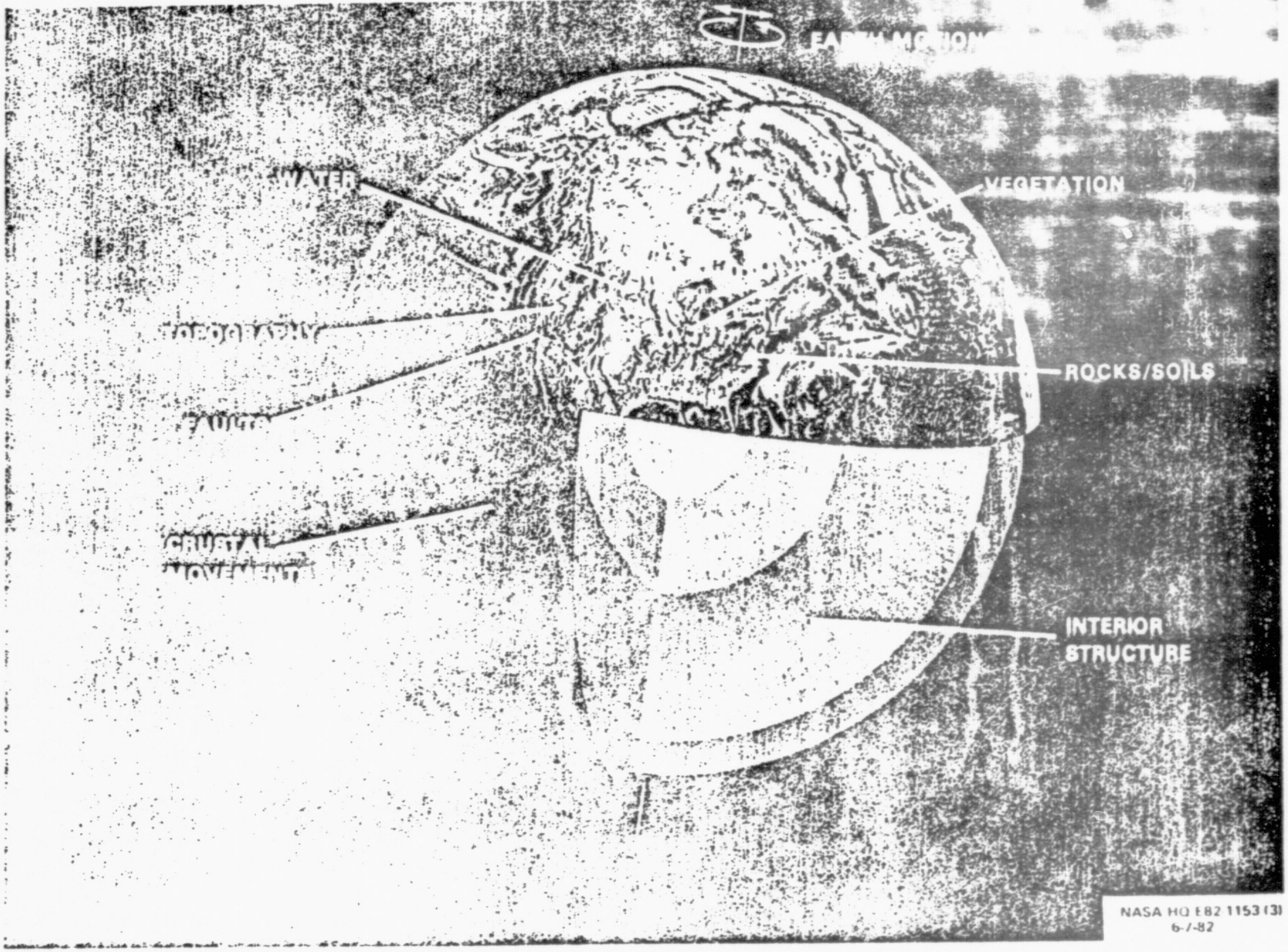

GEODYNAMICS
RADIO STAR
VERY LONG BASELINE INTERFEROMETRY
SATELLITE LASER RANGING
LAGEOS
MOON
LUNAR LASER RANGING
TECTONIC PLATE MOTION
MAY 1976—AUGUST 1981
POLAR MOTION
HIGH
LOW
NASA/GODDARD SPACE FLIGHT CENTER
GLOBAL DETAILED GRAVIMETRIC GEOID BASED UPON A COMBINATION OF
THE GSFC GEM 10B EARTH MODEL AND 1° · 1 SURFACE GRAVITY DATA
CONTOUR INTERVAL 2 METERS
GRAVITY FIELD



OPERATIONAL SPACECRAFT
VOYAGERS 1, 2
LANDSAT-3
MUTCH MEMORIAL STATION
PIONEER VENUS
PIONEERS 10-11


FLIGHT PROGRAMS
LANDSAT-D
GALILEO
LARGE FORMAT CAMERA
OSTA-3
DEPLOYED PANEL SET

EARTH AS A PLANET



NASA HQ E82 1153 (3)
6-7-82

Earth as a Planet

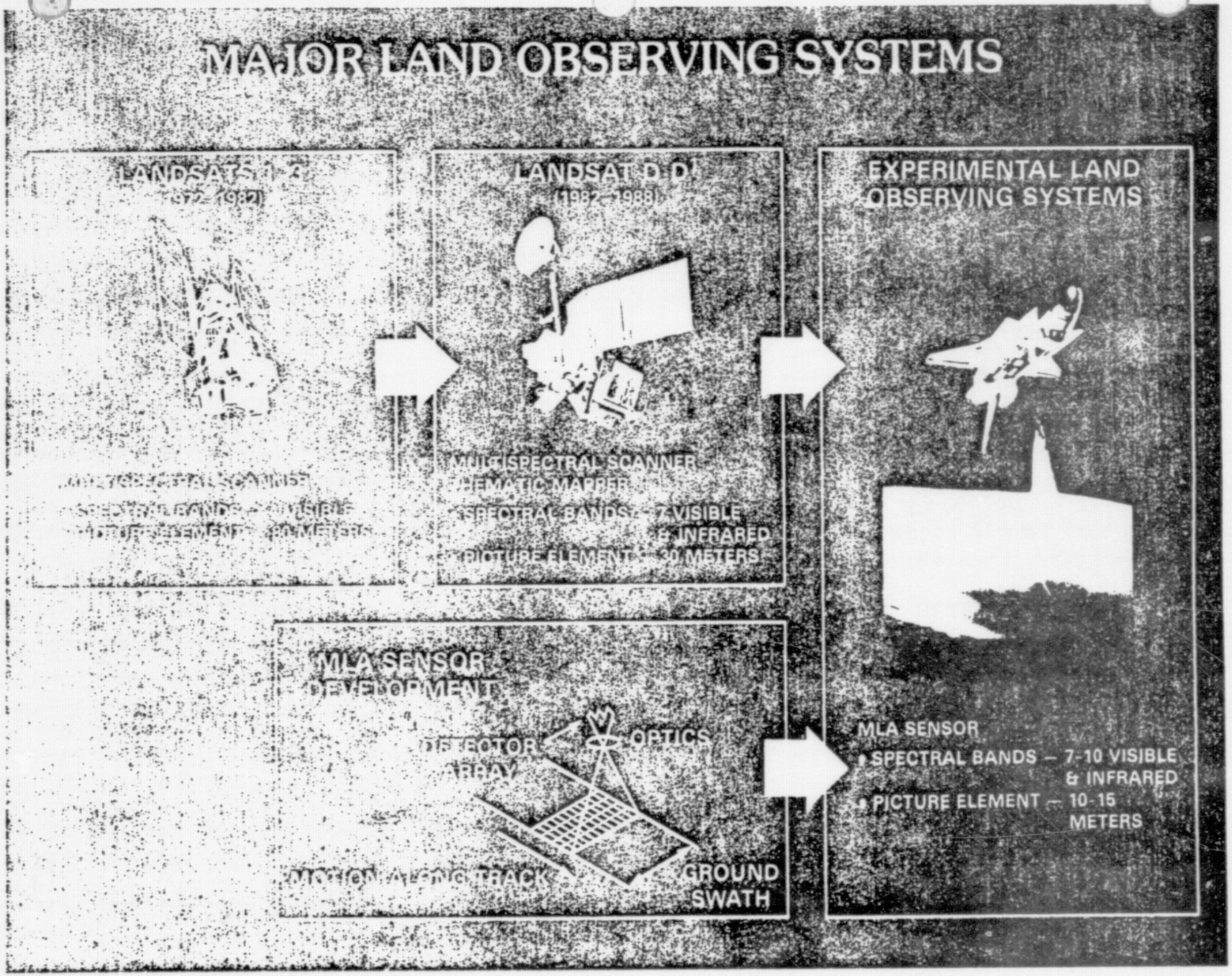
Strategy

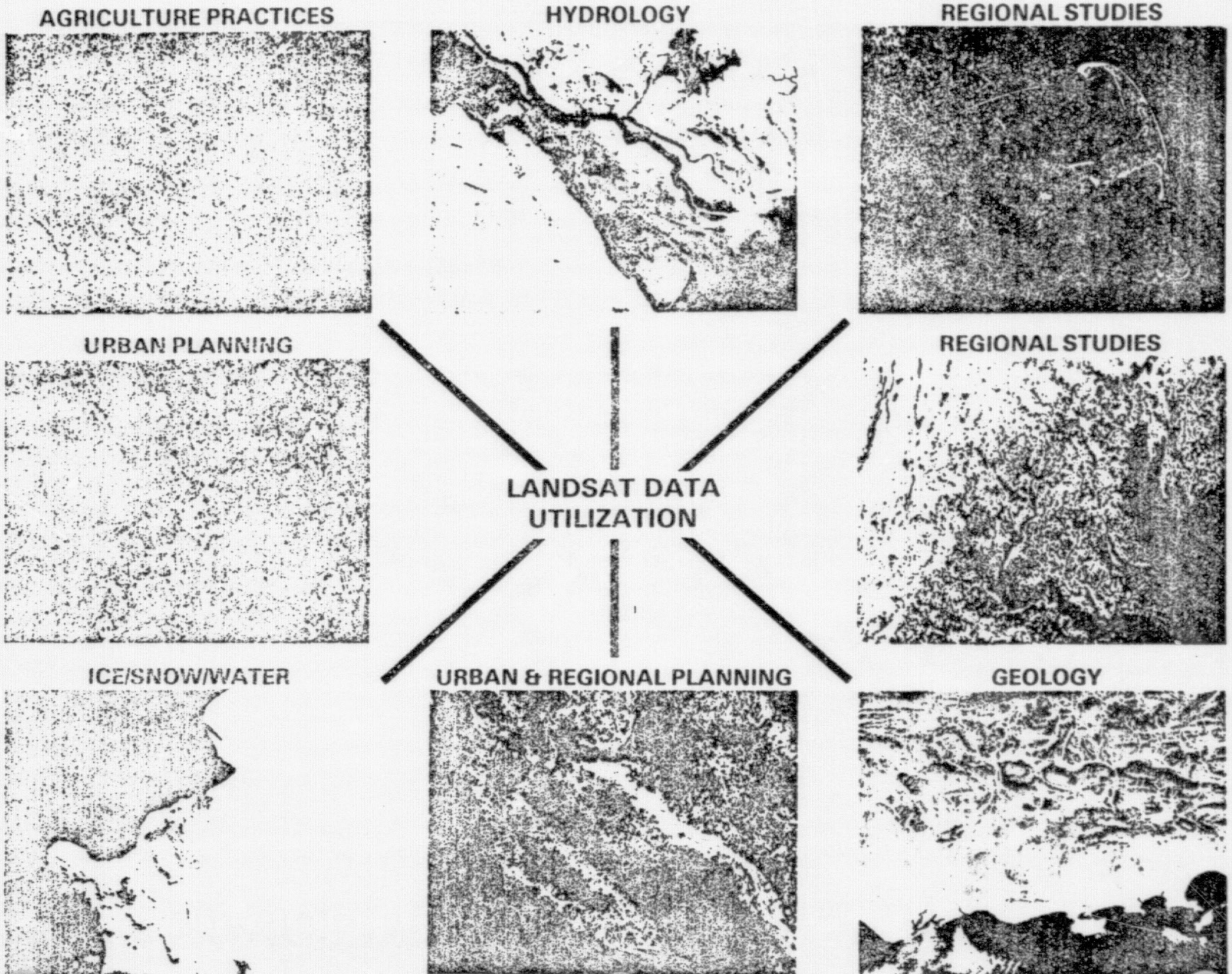
- Develop Fundamental Understanding of Remote Sensing Measurements and Information Extraction Methodologies

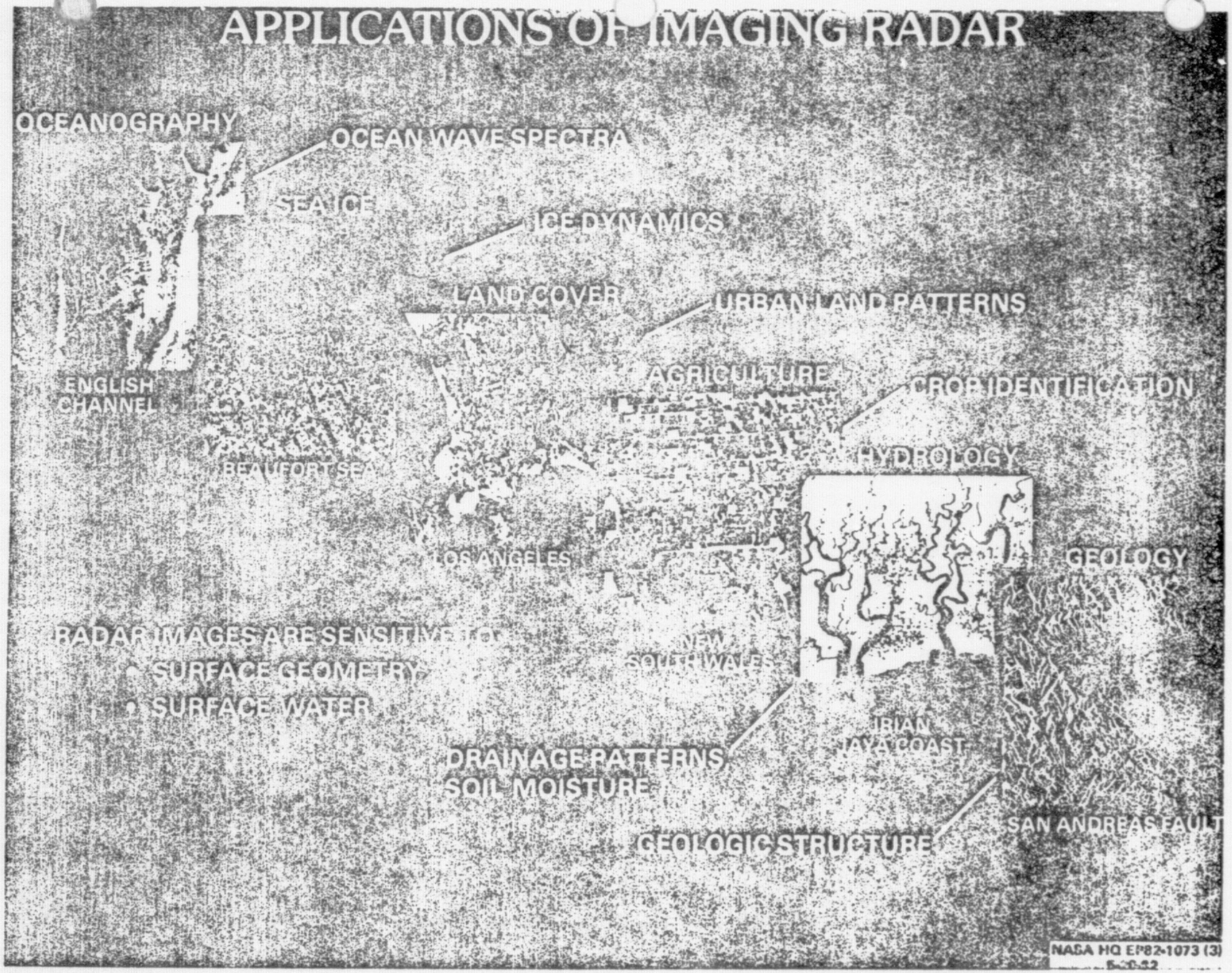
- Focus Research and Development
  - Agriculture Remote Sensing
  - Natural Resources
  - Solid Earth Geophysics

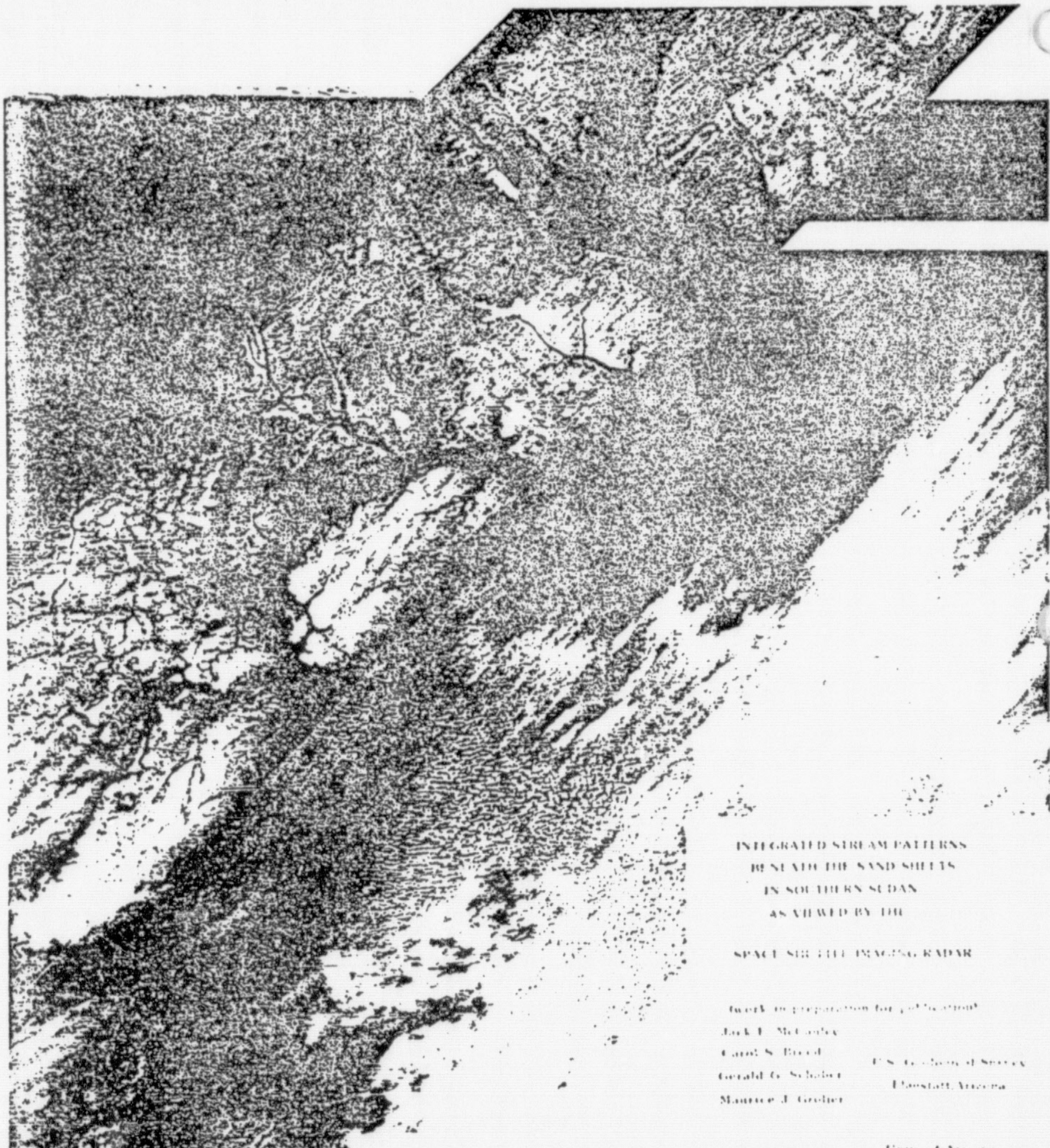
- Conduct Research/Development/Evaluation Programs in Cooperation with Other Research and User Organizations

- Emphasize Research and Development on Advanced:
  - Sensing Technology - Multilinear Arrays
  - Surveying and Positioning Technology - Lasers, VLBI, GPS Applications
  - Information Extraction Techniques for Radar

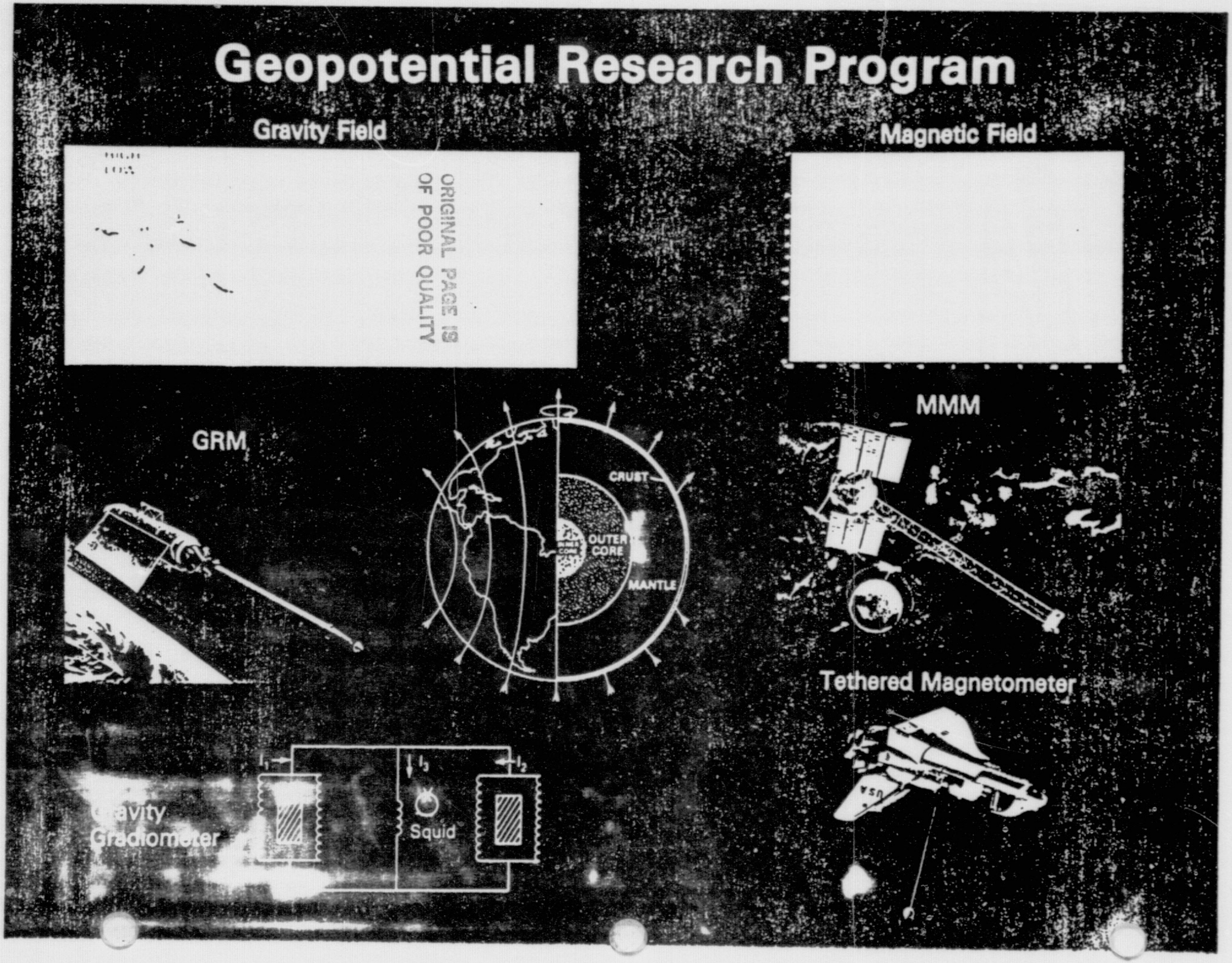

MAJOR LAND OBSERVING SYSTEMS
LANDSATS 1-3
(1972-1982)
LANDSAT D D'
(1982-1988)
MULTISPECTRAL SCANNER
THEMATIC MAPPER
SPECTRAL BANDS — 7 VISIBLE & INFRARED
PICTURE ELEMENT — 30 METERS
EXPERIMENTAL LAND OBSERVING SYSTEMS
MLA SENSOR DEVELOPMENT
DETECTOR ARRAY
OPTICS
MOTION ALONG TRACK
GROUND SWATH
MLA SENSOR
SPECTRAL BANDS — 7-10 VISIBLE & INFRARED
PICTURE ELEMENT — 10-15 METERS


AGRICULTURE PRACTICES
HYDROLOGY
REGIONAL STUDIES
URBAN PLANNING
LANDSAT DATA UTILIZATION
REGIONAL STUDIES
ICE/SNOW/WATER
URBAN & REGIONAL PLANNING
GEOLOGY

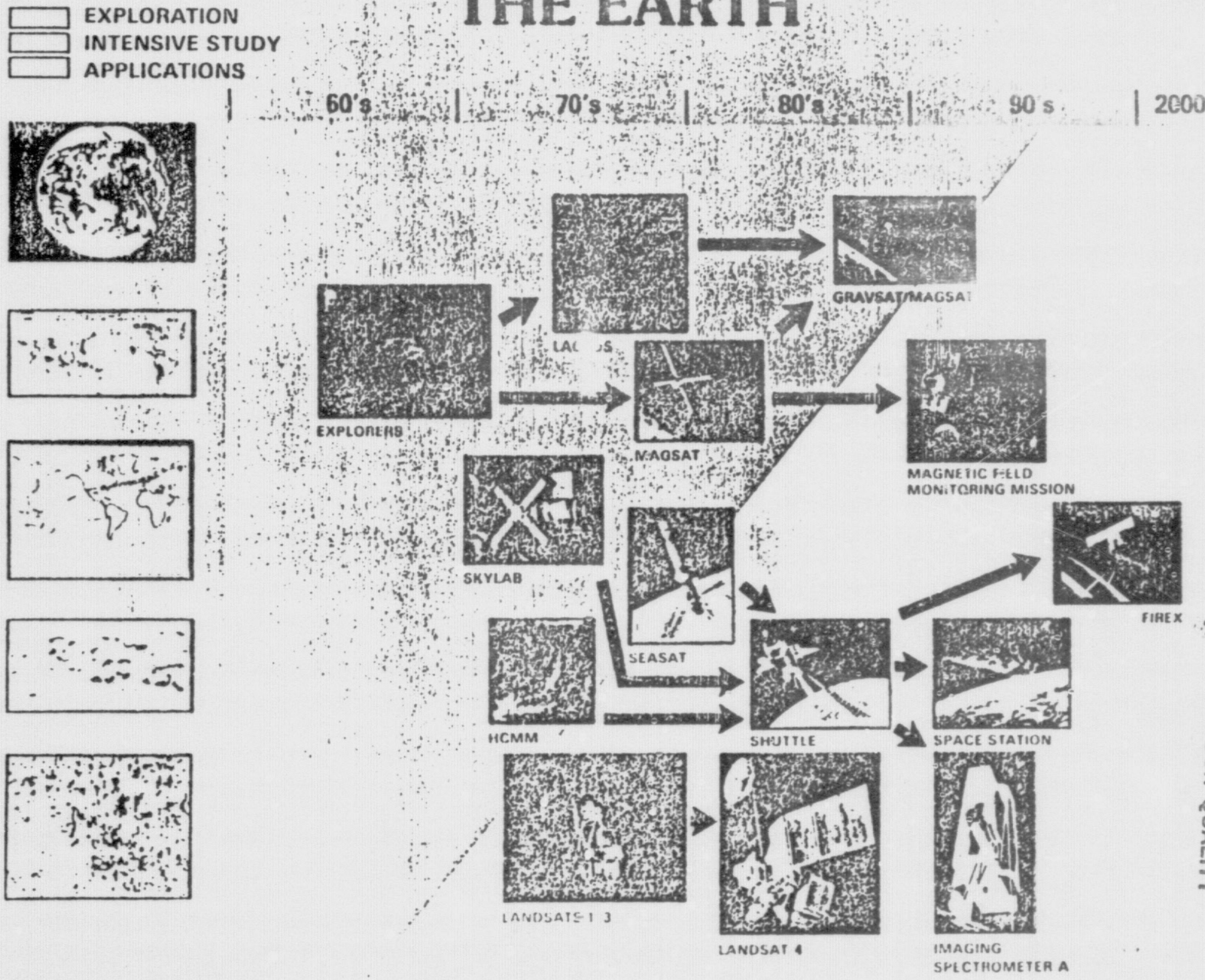

APPLICATIONS OF IMAGING RADAR
OCEANOGRAPHY
OCEAN WAVE SPECTRA
SEA ICE
ICE DYNAMICS
ENGLISH
CHANNEL
BEAUFORT SEA
LAND COVER
URBAN LAND PATTERNS
AGRICULTURE
CROP IDENTIFICATION
HYDROLOGY
LOS ANGELES
GEOLOGY
RADAR IMAGES ARE SENSITIVE TO:
• SURFACE GEOMETRY
• SURFACE WATER
NEW
SOUTH WALES
IRIAN
JAYA COAST
DRAINAGE PATTERNS
SOIL MOISTURE
SAN ANDREAS FAULT
GEOLOGIC STRUCTURE
NASA HQ EP82-1073 (3)



INTEGRATED STREAM PATTERNS
BENEATH THE SAND SHEETS
IN SOUTHERN SUDAN
AS VIEWED BY THE
SPACE SHUTTLE IMAGING RADAR
(work in preparation for publication)
Jack F. McCauley
Carol S. Breed
Gerald G. Schaber
Maurice J. Grolier
U.S. Geological Survey
Flagstaff, Arizona
C. Vance Haynes
Univ. of Arizona
Bahay Issawi
ENHANCED LANDSAT BAND 7
U.S. GEOLOGICAL SURVEY
FLAGSTAFF, ARIZONA


Geopotential Research Program
Gravity Field
Magnetic Field
GRM
CRUST
OUTER CORE
MANTLE
MMM
Tethered Magnetometer
Gravity Gradiometer
Squid
I_1
I_2
I_3

THE EARTH


EXPLORATION
INTENSIVE STUDY
APPLICATIONS
60's
70's
80's
90's
2000
EXPLORERS
GRAVSAT/MAGSAT
MAGSAT
MAGNETIC FIELD MONITORING MISSION
SKYLAB
SEASAT
FIREX
HCMM
SHUTTLE
SPACE STATION
LANDSATS 1-3
LANDSAT 4
IMAGING SPECTROMETER A

Solar System Exploration Methodology

Program Concept

- Develop a Scientific Exploration Strategy
  - NASA Working Groups
  - Space Science Board
- Develop a Mission Strategy to Implement Science
  - Iterative, Continuing Process

Science Strategy

- Discovery and Reconnaissance
  - First Look — Broad Band Instruments
  - Earth-Based Observations
  - Fly-By Spacecraft
- Exploration
  - Global Characterization — Physical State, Processes
  - High Resolution Instruments
  - Orbiters, Atmospheric Probes, Soft Landers
- Intensive Study
  - In-Depth Study, Refinement of Scientific Problems
  - Sophisticated Probes/Surface Vehicles
  - Sample Return
- Utilization/Exploitation
  - Inhabited Bases
  - Resource Use

Approach to Reduce Cost of Planetary Missions

- Focused Science Objectives
- Increased Flexibility Where Appropriate
  - Spacecraft
  - Launch Opportunities
- Increased Spacecraft Inheritance
  - Off-the-Shelf Earth Orbital Spacecraft (Pioneer Class)
  - Design (Mariner Mark II)
  - Instrument Multiple Use
  - Optimized Mission Sequence
- Increased Operations Efficiency
  - Reduced Trip Time (Launch Vehicle, Mission Type)
  - Shared Operations
  - Automation
  - Optimized Mission Sequence

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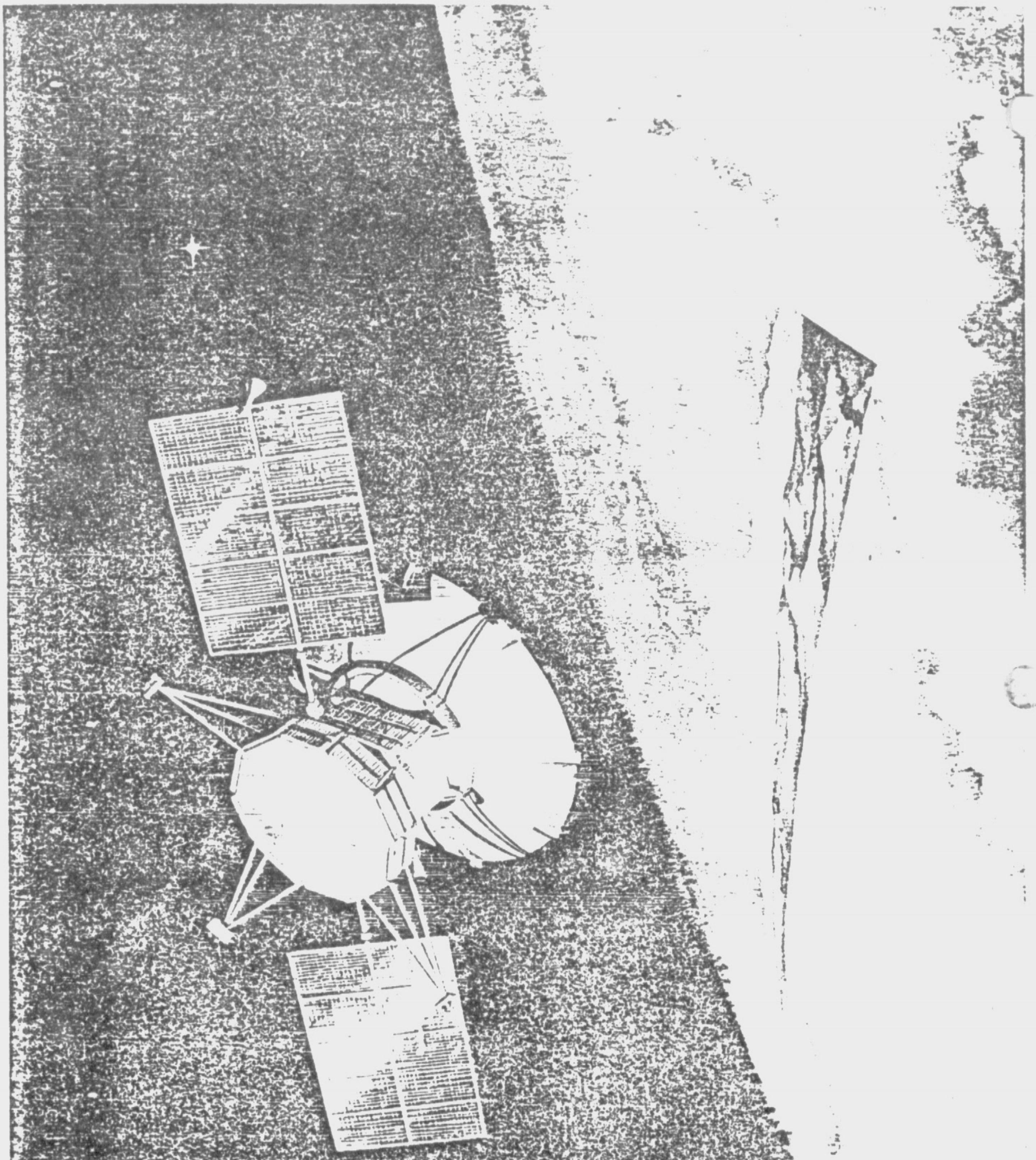


Venus Radar Mapping Mission

- Mission Science and Implementation Approach Endorsed By:
  - Solar System Exploration Committee
  - SSB/Committee on Planetary and Lunar Exploration
- VOIR Imaging Science Investigations to Be Used for Venus Mapper Science Team
- Mission Definition Study in Progress
  - Maximum Utilization of Available Voyager and Galileo Hardware
- Planned Procurement Approach
  - Rescope VOIR Radar (Hughes) and Spacecraft (MMC) Proposals
- Candidate FY 1984 New Initiative
  - April 1988 Launch: 2-Stage IUS

Solar System Observer Missions

Objective

- Provide for Low Cost, Frequent Earth and Planetary Flight Opportunities

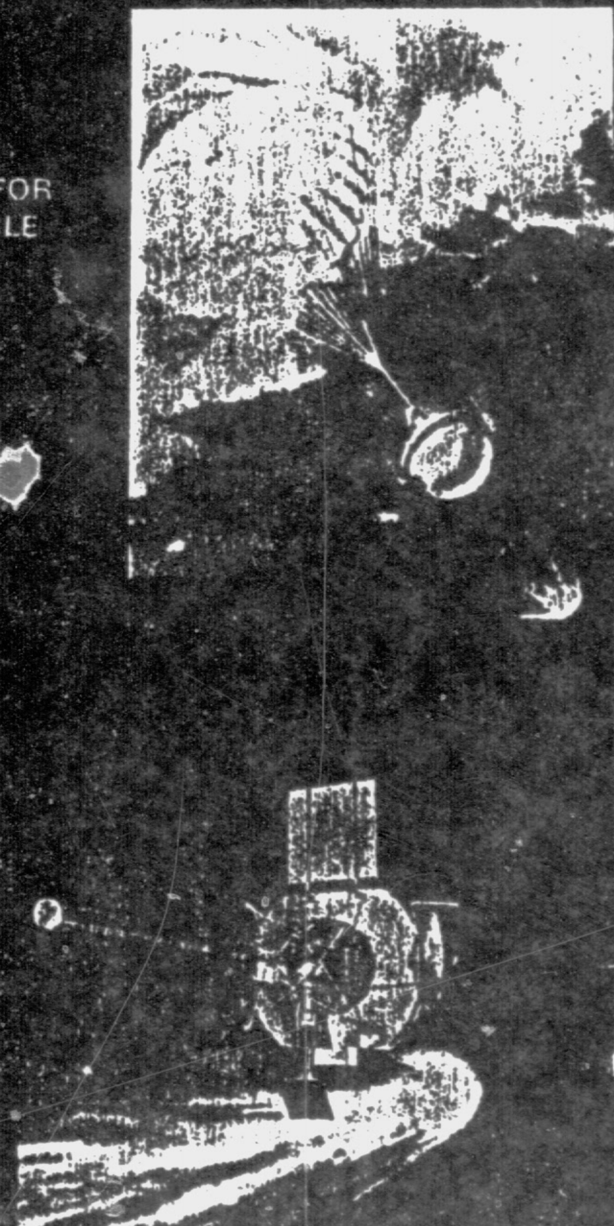
General Characteristics

- Missions of Opportunity
- Limited Scope
- Frequent Launches
- High Inheritance and/or Derivative Missions
- < $100M
- International Cooperation

Examples

- Solar Interplanetary Satellite
- Lunar Relay Satellite (Part of ESA POLO)
- Outer Planet Probe (U.S./CNES)

SOLAR SYSTEM EXPLORATION COMMITTEE



OBJECTIVE

DEVELOP LONG-TERM BALANCED MISSION STRATEGY FOR EXPLORATION OF SOLAR SYSTEM. IDENTIFY AFFORDABLE IMPLEMENTATION APPROACH

MEMBERSHIP

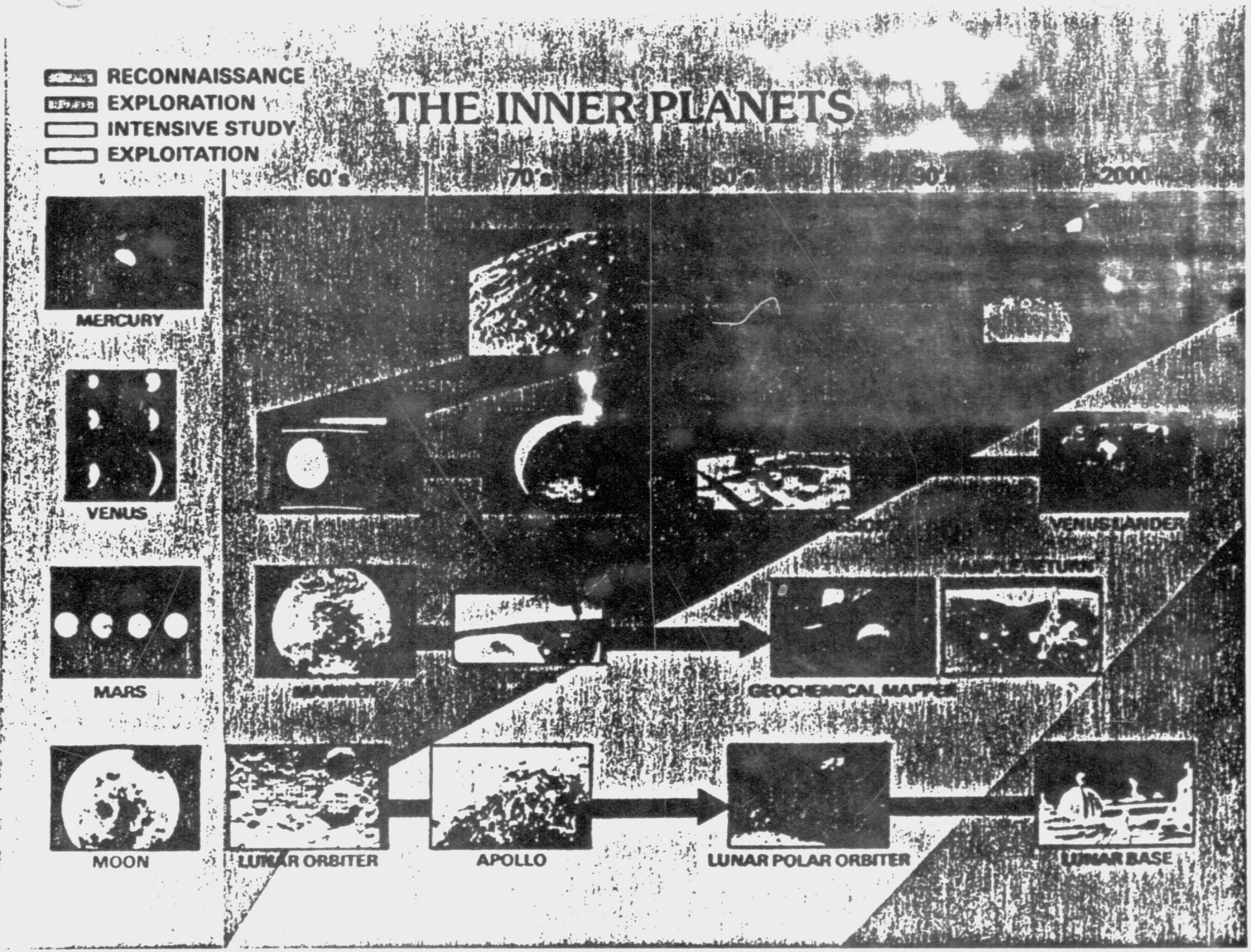
DR. NOEL HINNERS, NASM, CHAIRMAN
DR. GEOFFREY A. BRIGGS, EXECUTIVE DIRECTOR
DR. ARDEN ALBEE, CAL TECH
DR. EUGENE LEVY, UNIVERSITY OF AZ
DR. LAURENCE SODERBLOM, USGS
MR. JAMES S. MARTIN, MMC
DR. DAVID MORRISON, UNIVERSITY OF HI
DR. CHARLES A. BARTH, UNIVERSITY OF CO
DR. HAROLD MASURSKY, USGS
DR. TOBIAS C. OWEN, SUNY STONY BROOK
DR. KINSEY ANDERSON, UNIVERSITY OF CA BERKELEY
DR. HAROLD P. KLEIN, NASA/ARC
DR. JOSEPH VEVERKA, CORNELL
DR. JAMES ARNOLD, UNIVERSITY OF CA SAN DIEGO
MR. JOHN NIEHOFF, SAI
DR. THOMAS DONAHUE, UNIVERSITY OF MI
DR. LENNARD A. FISK, UNIVERSITY OF NH
DR. JOHN E. NAUGLE

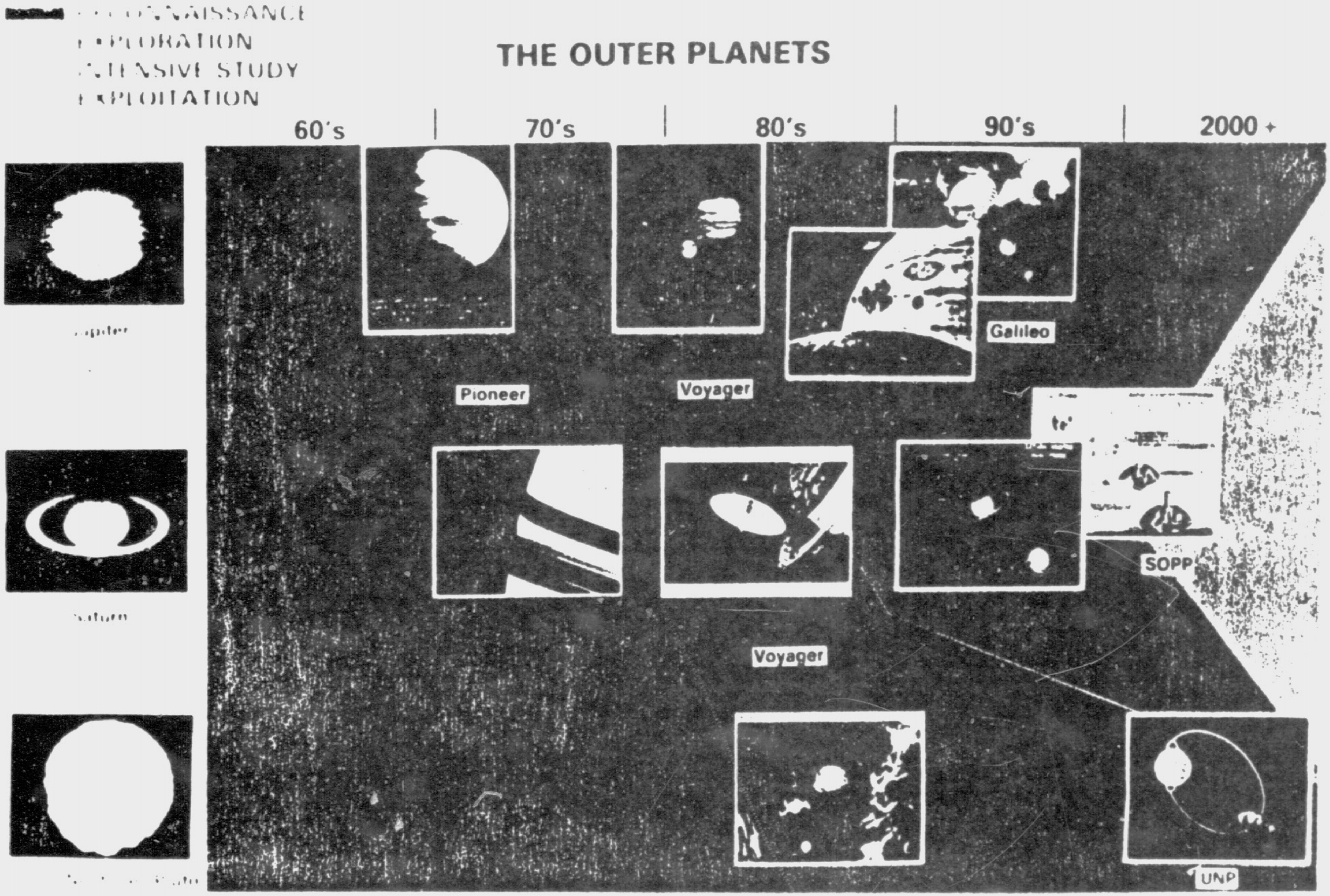
SSEC Interim Recommendations

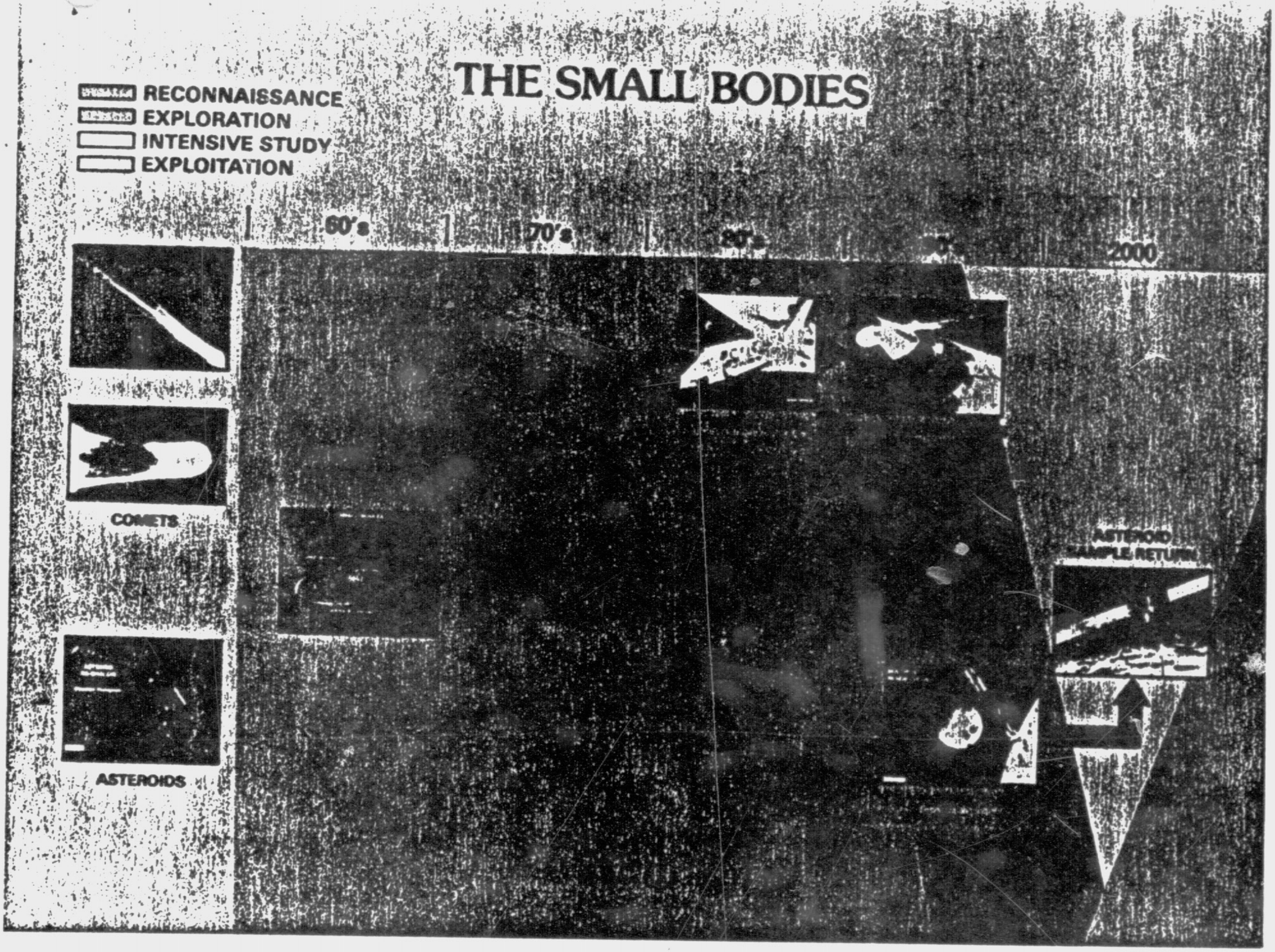
- Balanced Program of Science and Exploration Remains Goal
- Venus Mapping Mission Is High Priority, and Development Should Be Initiated as Soon as Possible
- Future Flight Program Should Contain:

Inner Solar System:	Lunar Polar Orbiter, Mars Geochemical Orbiter, Mars Climatology Orbiter, Mars Aeronomy Mission, Venus Probe, Mars Network
Outer Planets:	Titan Probe, Saturn Probe, Uranus Probe, Neptune Probe, Saturn Orbiter
Small Bodies:	Comet Rendezvous, Comet Plasma Sample Return, Multiasteroid Rendezvous, Near-Earth Asteroid Rendezvous

- Affordable Implementation Approaches Must Be Developed
- Additional Opportunities Should Be Found for Ambitious Technology — Driving Missions
- Development of High Energy Upper Stage for Shuttle Would Reduce Mission [illegible]ance Science of Some Missions
- [illegible]elopment of Upper Stage Capability Intermediate Between PAM and IUS Could Re[illegible] Overall Costs of Interplanet Missions


THE INNER PLANETS
RECONNAISSANCE
EXPLORATION
INTENSIVE STUDY
EXPLOITATION
60's
70's
80's
90's
2000
MERCURY
VENUS
MARS
MOON
VENUS LANDER
GEOCHEMICAL MAPPER
LUNAR ORBITER
APOLLO
LUNAR POLAR ORBITER
LUNAR BASE


THE OUTER PLANETS
60's
70's
80's
90's
2000 +
Pioneer
Voyager
Galileo
SOPP
Voyager
UNP


THE SMALL BODIES
RECONNAISSANCE
EXPLORATION
INTENSIVE STUDY
EXPLOITATION
60's
70's
80's
2000
COMETS
ASTEROIDS
ASTEROID
SAMPLE RETURN

EARTH AND PLANETARY LXPLORATION

POTENTIAL USES OF SPACE STATION

- OBSERVATIONS OF EARTH
- OBSERVATIONS OF PLANETARY SYSTEMS
- ON-ORBIT LABORATORY
- STAGING OF HIGH ENERGY MISSIONS
- ON-ORBIT RESEARCH AND DEVELOPMENT

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

OBSERVATIONS OF EARTH

- o EARTH SCIENCES RESEARCH
  - LAND RESOURCES
  - GEOPHYSICAL INVESTIGATIONS
- o DETECTION AND MONITORING OF EPISODIC EVENTS
  - CRUSTAL HAZARDS
  - FLOODING, INFESTATIONS, CROP DISEASES
- o OPERATIONAL LAND SYSTEMS
  - GLOBAL COVERAGE

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

<u>EARTH SCIENCES RESEARCH</u> (LAND RESOURCES)

- PURPOSE: TO ACQUIRE SPECTRUM WIDE MULTIBAND DATA OF GLOBAL LAND AREAS FOR EARTH RESOURCES RESEARCH IN BIOMASS, HYDROLOGY, LAND USE, AND GEOSCIENCES

- TYPICAL INSTRUMENTS

  - HIGH RESOLUTION, MULTIBAND PROGRAMMABLE IMAGING SPECTROMETER (VIS -- TIR)
  - MULTIFREQUENCY SAR
  - HIGH RESOLUTION MICROWAVE IMAGERS (20-30M ANTENNAS)
  - ACTIVE AND PASSIVE FLUORESCENCE SPECTROMETERS
  - DIGITAL TOPOGRAPHIC MAPPER
  - LONG WAVELENGTH SUBSURFACE SOUNDERS

- REQUIREMENTS ON CARRIERS

  - HIGH INCLINATION ORBIT
    - -- ADJUSTABLE GROUND TRACK REPEAT CYCLE
  - PRECISION POINTING
  - STABLE INSTRUMENT BASE
  - CAPABILITY TO SELECT AND COMMAND INSTRUMENTS
  - REAL-TIME DATA PROCESSING AND DISPLAY
  - DATA RATE (MBPS → GBPS)
  - POWER -- 10 KW
  - CONTAMINATION FREE ENVIRONMENT (PARTICULATE, GASEOUS, SCATTERED LIGHT, RFI)
  - CAPABILITY TO MAINTAIN AND CHANGE-OUT INSTRUMENTS
  - ACCURATE EPHEMERIS DATA (REAL-TIME)

EARTH AND PLANTEARY EXPLORATION

POTENTIAL USES OF SPACE STATION

<u>EARTH SCIENCES RESEARCH</u> (GEOPHYSICAL INVESTIGATIONS)

- o PURPOSE:
  - TO MAP TIME-VARIANT CHANGES IN THE EARTH'S MAGNETIC FIELD AND TO MAP CRUSTAL MAGNETIC ANOMALIES.
- o TYPICAL INSTRUMENTS:
  - VECTOR AND SCALAR MAGNETOMETERS
  - MAGNETIC FIELD GRADIOMETER
- o REQUIREMENTS ON CARRIER:
  - NEAR POLAR COVERAGE
  - EXTENDABLE BOOM ($\sim$ 100 METERS)
  - GLOBAL SURVEYS AT SIX-MONTH INTERVALS
  - ACCURATE EPHEMERIS ($\pm$ 10 METERS)
  - TETHERED SUBSATELLITE (FOR ANOMALY STUDIES)

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

DETECTION AND MONITORING OF EPISODIC EVENTS

- o PURPOSE:

  MONITORING OF AREAS WITH HIGH SUSCEPTABILITY TO CRUSTAL HAZARDS (EARTHQUAKES, VOLCANIC ERUPTIONS, LANDSLIDES), FLOODING, INFESTATION, ETC.

- o TYPICAL INSTRUMENTS:

  - CRUSTAL HAZARDS

    -- SPACEBORNE PULSE LASER
    -- GROUND-BASED CORNER CUBE RETROREFLECTORS

  - FLOODING, INFESTATIONS, CROP DISEASES

    -- MULTIBAND PROGRAMMABLE IMAGING SPECTROMETER (VIS -- TIR)
    -- MULTIFREQUENCY SAR
    -- MULTIBAND THERMAL IR IMAGER

- o REQUIREMENTS ON CARRIER:

  - $\pm 60^0$ LATITUDE COVERAGE
  - 2-5 DAYS REPEAT CYCLE
  - POINTABLE INSTRUMENT PLATFORMS
  - REAL-TIME DATA PROCESSING (INCLUDING MERGING OF DATA SETS)
  - INTERACTIVE REAL-TIME DATA DISPLAY
  - CAPABILITY TO SELECT AND CONTROL INSTRUMENTS
  - ON-ORBIT MAINTENANCE
  - DIRECT TWO-WAY COMMUNICATIONS WITH GROUND TEAMS
  - DATA RATE--SEVERAL HUNDRED MBPS

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

OPERATIONAL LAND SYSTEMS

- PURPOSE: TO ACQUIRE MULTISPECTRAL COVERAGE OF GLOBAL LAND AREAS FOR OPERATIONAL EARTH RESOURCES EXPLORATION AND MONITORING

- TYPICAL INSTRUMENTS

  - PUSHBROOM IMAGER (VISIBLE/NIR/SWIR)
  - DUAL FREQUENCY SAR
  - MICROWAVE RADIOMETERS
  - MULTIBAND THERMAL IR IMAGER

- REQUIREMENTS ON CARRIER

  - NEAR-POLAR SUN SYNCHRONOUS ORBIT, A.M. EQUATORIAL CROSSING
  - 500-1,000 KM ALTITUDE
  - 7-10 DAY GROUND TRACK REPEAT CYCLE
  - NEAR CONTINUOUS NADIR VIEWING
  - STABLE PLATFORMS
  - MOUNTING FOR LARGE ANTENNAS (PARABOLIC AND SAR)
  - DATA RATE $>$ 300 MBPS (COMPRESSED)
  - POWER -- 10 KW (PEAK)
  - CONTAMINATION-FREE ENVIRONMENT
  - COMMAND/CONTROL UPLINK (TASKING)
  - ACCURATE EPHEMERIS DATA (IN REAL-TIME DATA STREAM)
  - ON-ORBIT MAINTENANCE AND REPAIR

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

OBSERVATIONS OF PLANETARY SYSTEMS

- o SOLAR SYSTEM OBSERVATIONS
  - LONG-TERM COMPREHENSIVE STUDIES
  - TRACKING OF MOVING TARGETS
- o SEARCH FOR EXTRASOLAR PLANETS
  - "SPACE TELESCOPE" SIZE OBSERVING SYSTEM
  - ACCURATE POINTING AND STABLE BASE FOR NEAR CONTINUOUS OBSERVATIONS

POTENTIAL USES OF SPACE STATION

SOLAR SYSTEM OBSERVATIONS

o PURPOSE:

TO CONDUCT LONG-TERM COMPREHENSIVE STUDIES OF THE COMPOSITION, STRUCTURE, AND DYNAMICS OF PLANETARY ATMOSPHERES AND MAGNETOSPHERES; OBSERVATIONS OF COMETS AND ASTEROIDS; OBSERVATIONS OF PLANETARY SURFACES AND "TARGETS OF OPPORTUNITY" (E.G., MARTIAN DUST STORMS, NEW BRIGHT COMETS); AND COLLECTION OF EXTRATERRESTRIAL MATERIALS (DUST, SOLAR WIND, COSMIC RAYS)

o TYPICAL INSTRUMENTS

- LARGE DIAMETER TELESCOPE (~ 3-5M)
  - -- UV, EUV, AND IR SPECTROGRAPHS
  - -- IMAGING SPECTROMETER (UV → IR)
- LARGE IR-SUBMILLIMETER TELESCOPE
- WIDE FIELD TELESCOPE (1M)
- IN SITU COLLECTORS

o REQUIREMENTS ON CARRIER

- POINTING
  - ACCURACY 0.01 $\widehat{SEC}$
  - STABILITY 0.005 $\widehat{SEC}$
- CAPABILITY FOR OFF-SET POINTING
- CAPABILITY TO TRACK MOVING TARGETS
- CHANGE-OUT OF FOCAL PLANE INSTRUMENTS
- REPLENISHMENT OF CRYOGENS AND IN SITU COLLECTORS
- CONTAMINATION-FREE ENVIRONMENT (PARTICULATE, GASEOUS, SCATTERED LIGHT)
- RETURN OF MATERIALS COLLECTORS TO EARTH

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

<u>SEARCH FOR EXTRASOLAR PLANETS</u> (PLANETARY DETECTION SYSTEM)

- o PURPOSE: TO CONDUCT A SYSTEMATIC SEARCH FOR OTHER PLANETARY SYSTEMS
- o INSTRUMENTS:
  - 3M DIAMETER TELESCOPE, APPROXIMATELY 10M IN LENGTH
- o REQUIREMENTS (IMAGING SYSTEM)
  - POINTING
    ACCURACY 0.01 SEC
    STABILITY 0.007 SEC
  - INTEGRATION TIME UP TO 15 HOURS (OVER MANY ORBITS)
  - MASS 10,000 KG
  - POWER 1 KW (AVG)
  - PRECISE TEMPERATURE CONTROL
  - UPLINK COMMAND CAPABILITY 1 KBPS
  - DATA RATE 200 KBPS
  - CONTAMINATION-FREE ENVIRONMENT

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

<u>ON-BOARD LABORATORY</u>

- <u>PURPOSE:</u>

  TO SIMULATE EARLY PLANETARY CONDITIONS IN ORDER TO ACQUIRE EXPERIMENTAL INFORMATION ON THE EFFECTS OF LOW GRAVITY AND/OR PRESSURE ON PLANETARY PHYSICAL PROCESSES

- <u>EXPERIMENTAL INVESTIGATIONS:</u>

  - LOW GRAVITY SEDIMENT TRANSPORT
  - CRATERING PHENOMENA AT LOW-G
  - ACCRETIONAL PHENOMENA
  - CONDENSATION AND AGGLOMERATION OF DUST PARTICLES AT HIGH TEMPERATURES (SILICATES)
  - EROSIONAL MECHANISMS AT LOW-G (WIND, LIQUID)

- <u>REQUIREMENTS:</u>

  - LABORATORY ENVIRONMENT (SHIRT-SLEEVE)
  - TRAINED PLANETOLOGISTS
  - EQUIPPED LABORATORY
    - -- CENTRIFUGE
    - -- HIGH TEMPERATURE FURNACE
    - -- LOW SPEED WIND TUNNEL
    - -- CLOUD CHAMBER
    - -- LEVITATION SYSTEM
    - -- PROJECTILE ACCELERATOR
    - -- ON-BOARD COMPUTATIONAL SYSTEM
    - -- HIGH SPEED CAMERAS
    - -- ACCRETION/CONDENSATION FACILITY
  - DOWNLINK HIGH RESOLUTION TV
  - TWO WAY VOICE COMMUNICATIONS

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

STAGING OF HIGH ENERGY MISSIONS

- o PURPOSE: TO LAUNCH GEOSYNCHRONOUS AND PLANETARY MISSIONS FROM A SPACE STATION IN LOW EARTH ORBIT

- o FUNCTIONS TO BE PERFORMED ON SPACE STATION

  STORAGE

  ASSEMBLY

  SERVICING

  CHECKOUT

  DEPLOYMENT

  RECOVERY

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

STAGING OF HIGH ENERGY MISSIONS

- o STORAGE

  PROPELLANT
  PROPULSION STAGES (BERTHING PORT)
  SPACECRAFT PAYLOADS (BERTHING PORT)

- o ASSEMBLY

  SPACECRAFT SYSTEMS - MULTIELEMENT
  MATING SPACECRAFT WITH PROPULSION STAGES

- o SERVICING

  PROPELLANT LOAD OF STAGES
  STAGE SUBSYSTEM REPAIR/REPLACEMENT
  SPACECRAFT SUBSYSTEM REPAIR/REPLACEMENT
  RTG MAINTENANCE SUPPORT (COOLING, SHIELDING)

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

STAGING OF HIGH ENERGY MISSIONS (CON'T)

- TEST AND CHECKOUT (PRE-LAUNCH)

  STAGES (PROPELLANT, TANKS, LINES, ENGINE, CONTROL)
  SPACECRAFT (SCIENCE PAYLOADS, SUPPORTING SUBSYSTEMS)
  LAUNCH CONFIGURATION

- DEPLOYMENT (LAUNCH)

  STATION ORBIT DETERMINATION UPDATE
  LAUNCH ON-TIME CAPABILITY ($\pm$ 2 DAYS)
  VEHICLE/STATION SEPARATION (CONTROL AND MONITOR)
  MONITOR STAGE BURN AT DISTANCE (VISUAL AND TELEMETRY)
  INTERFACE WITH GROUND COMMAND/TRACKING

- RECOVERY

  REUSABLE PROPULSION STAGES
  PAYLOAD (SAMPLE) RETURN, QUARANTINE AND TESTING

EARTH AND PLANETARY EXPLORATION

POTENTIAL USES OF SPACE STATION

SUMMARY

- o MOST SIGNIFICANT DETERIMANT OF UTILITY OF SPACE STATION TO LAND REMOTE SENSING IS SELECTION OF ORBITAL PARAMETERS
  - NEAR POLAR/HIGH INCLINATIONS REQUIRED FOR EARTH SCIENCES RESEARCH COMPLEMENT
  - FREQUENT GROUND TRACK REPEAT CYCLES
  - NEAR POLAR SUN SYNCHRONOUS ORBIT REQUIRED FOR OPERATIONAL TYPE SYSTEMS
- o MAN TENDING OF PAYLOADS BENEFICIAL
- o PLATFORM FOR LONG-TERM COMPREHENSIVE OBSERVATIONS OF PLANETARY SYSTEMS
  - LOW INCLINATION ORBITS ADEQUATE
- o POTENTIAL ADVANTAGES FOR STAGING OF HIGH ENERGY MISSIONS
- o ON-ORBIT MANNED LABORATORY

MATERIALS PROCESSING IN SPACE (MPS)

GOAL

PROVIDE RESEARCH BASE AND ESTABLISH STS FACILITY USAGE

- TO ACHIEVE IMPROVED PROCESSING METHODS AND MATERIALS OF TECHNOLOGICAL INTEREST
- TO ASSIST EARLY COMMERCIALIZATION OF SPACE PROCESSING

CURRENT AREAS OF ACTIVITY

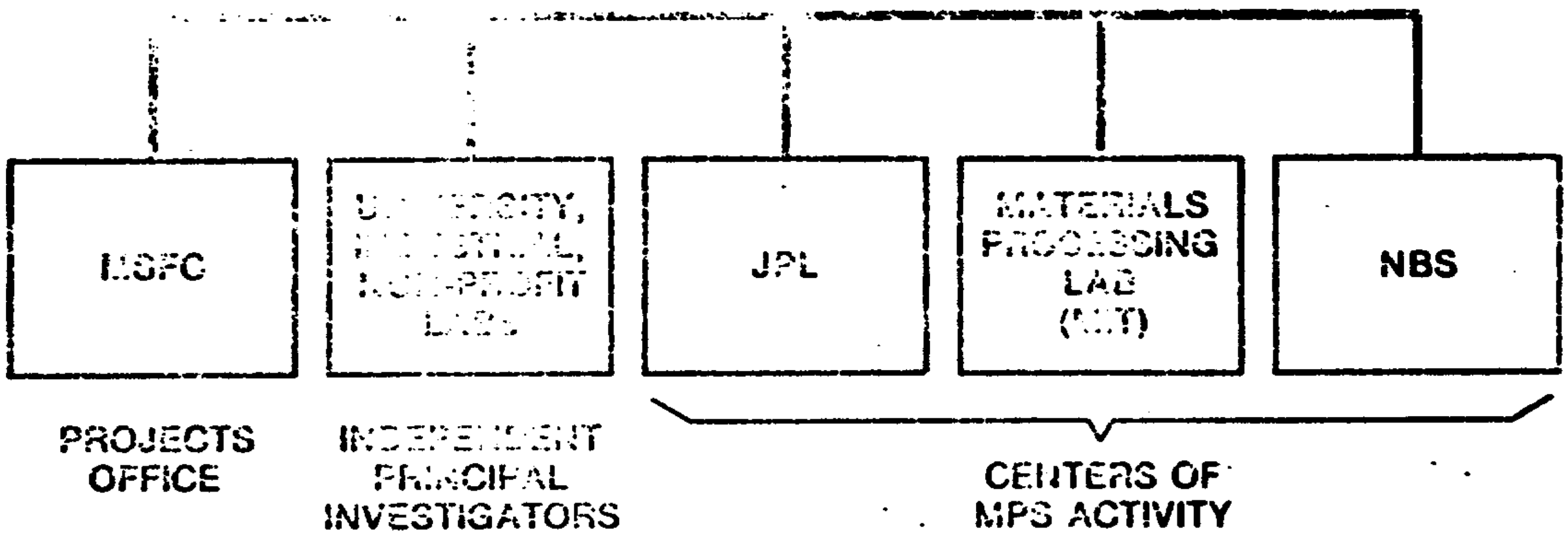
- CRYSTAL GROWTH
- SOLIDIFICATION
- FLUID AND CHEMICAL PROCESSES
- CONTAINERLESS PROCESSING
- BIOLOGICAL MATERIALS SEPARATION

MPS APPLIED RESEARCH AND DATA ANALYSIS

AREA	THRUST
(1) CONTAINERLESS TECH.	DEVELOPMENT OF UNIQUE STATE OF ART PROCESSING TECHNOLOGY, ACOUSTIC, ELECTROSTATIC, ELECTROMAGNETIC, JET. WE ARE LEADERS IN THIS FIELD.
(2) CONTAINERLESS SCIENCE	HIGH PURITY GLASSES NEW OXIDE GLASSES HIGH TEMPERATURE PROCESSING HIGH TEMPERATURE THERMOPHYS. MEAS. CORROSIVE REACTIONS BASIC NUCLEATION STUDIES FUSION TARGET TECHNOLOGY
(3) CRYSTAL GROWTH	GROWTH FROM VAPOR GROWTH FROM SOLUTION GROWTH FROM MELT
(4) SOLIDIFICATION PROCESS	UNDERSTANDING CASTING REDUCING CONVECTIVE EFFECTS IMMISCIBLE MATERIALS COOPERATIVE GROWTH
(5) SPACE MATERIALS SYSTEM	DEVELOPMENT OF REQUIREMENTS AND TECHNIQUES FOR EXTRA TERRESTRIAL MATERIALS PROC.

AREA	THRUST
(6) BIOLOGICAL PROCESSING	SEPARATION TECHNIQUES SEPARATION OF VIABLE CELLS SEPARATION OF PROTEIN
(7) FLUID BEHAVIOR	FLUID DYNAMICS OF SPACE PROCESSING CRITICAL POINT PHENOMENA
(8) PROGRAM SUPPORT	SCIENCE & DISCIPLINE WORKING GROUPS, OUTSIDE PEER REVIEW SUPPORT
(9) COMMERCIAL MPS	IDENTIFY COMPANIES AND ARRANGEMENTS FOR COMMER.
(10) COMBUSTION	INFLUENCE OF CONVECTION ON COMBUSTION
(11) CLOUD PHYSICS	INFLUENCE OF CONVECTION ON CLOUD FORMATION

MPS SCIENCE BASE



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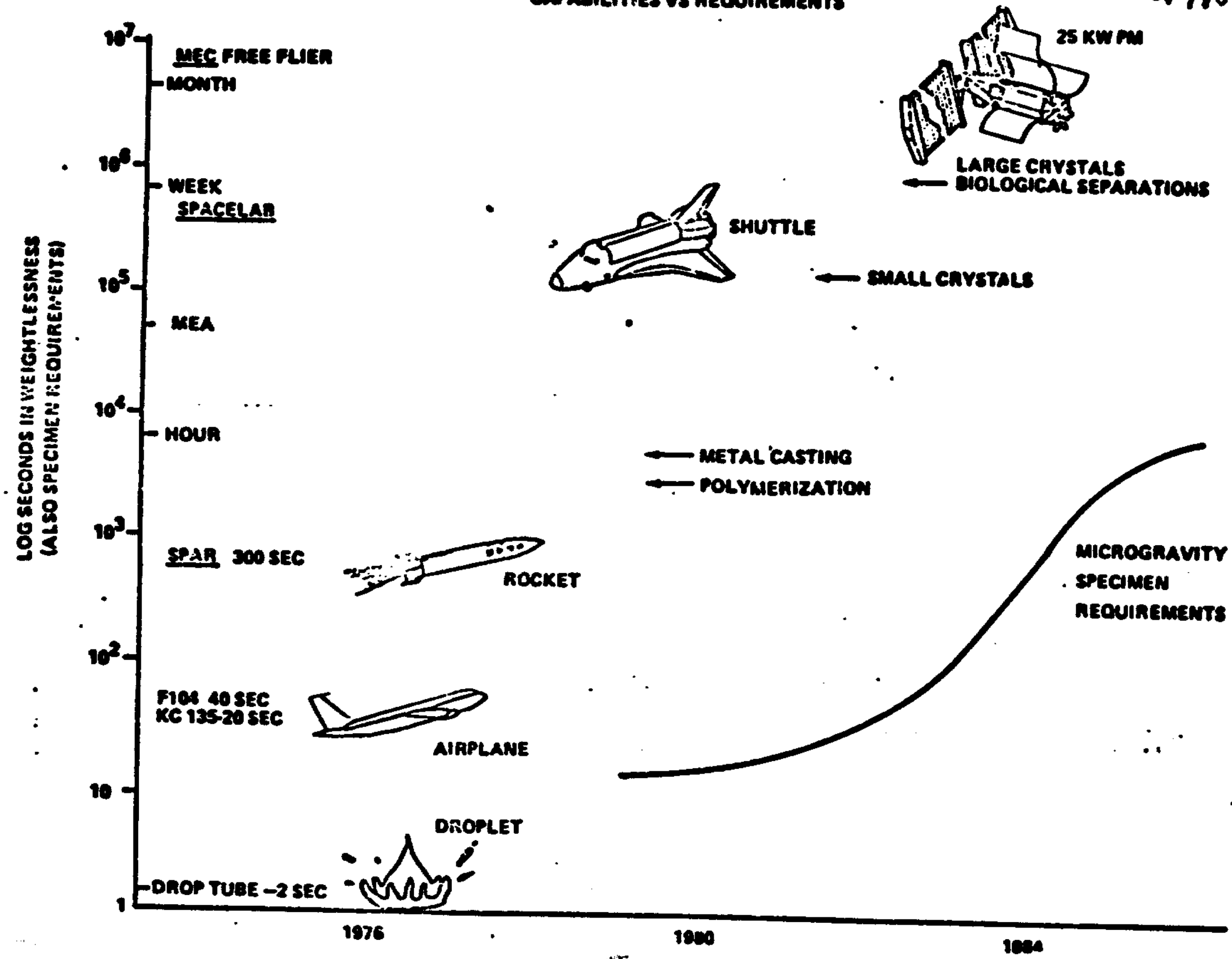
MATERIALS PROCESSING IN SPACE

2
8/4/80

LOW GRAVITY DURATION
CAPABILITIES VS REQUIREMENTS



SKYLAB EXPERIMENTS

M552 EXOTHERMIC BRAZING
Mr. J. R. Williams (MSFC)

M551 METALS MELTING
Mr. E. C. McKannan (MSFC)

M553 SPHERE FORMING
Dr. D. J. Larson (Grumman Aerospace)

M479 ZERO GRAVITY FLAMMABILITY
Mr. J. H. Kimzey (Johnson Space Flight Center)

M518 MULTIPURPOSE FURNACE
Mr. W. R. Adams (MSFC)

M557 IMMISCIBLE ALLOY COMPOSITIONS
Mr. J. L. Reger (TRW)

M565 SILVER GRIDS MELTED IN SPACE
Prof. E. Aernoudt (Catholic U., Leuven, Belgium)

M561 WHISKER REINFORCED COMPOSITES
Dr. S. Takahashi (National Research Institute for Metals, Tokyo, Japan)

M556 VAPOR GROWTH OF IV-VI COMPOUNDS
Prof. H. Wiedemeier (Rensselaer Polytechnic Institute)

M560 GROWTH OF SPHERICAL CRYSTALS
Dr. H. U. Walter (University of Alabama in Huntsville)

M562 INDIUM ANTIMONIDE CRYSTALS
Prof. A. F. Witt (Massachusetts Institute of Technology)

M563 MIXED III-V CRYSTAL GROWTH
Prof. W. R. Wilcox (University of Southern California)

M559 MICROSEGREGATION IN GERMANIUM
Dr. J. T. Yue (Texas Instruments, Inc.)

M558 RADIOACTIVE TRACER DIFFUSION
Dr. A. O. Ukanwa (Howard University)

M566 COPPER-ALUMINUM EUTECTIC
Mr. E. A. Hasemeyer (MSFC)

M564 METAL AND HALIDE EUTECTICS
Dr. A. S. Yue (University of California, Los Angeles)

SKYLAB SCIENCE DEMONSTRATIONS

(NO NUMBER)	DIFFUSION IN LIQUIDS
(NO NUMBER)	ICE MELTING
TV101	LIQUID FLOATING ZONE
TV102	IMMISCIBLE LIQUIDS
TV103	LIQUID FILMS
TV105	ROCHELLE SALT GROWTH
TV106	DEPOSITION OF SILVER CRYSTALS
TV107	FLUID MECHANICS
TV117	CHARGED PARTICLE MOBILITY

ASTP EXPERIMENTS

ELECTROPHORESIS TECHNOLOGY (MA-011)

R. E. ALLEN, G. H. BARLOW, M. BIER, P. E. BIGAZZI, R. J. KNOX, F. J. MICALE, G. V. F. SEAMAN, J. W. VANDERHOFF, C. J. VAN OSS, W. J. PATTERSON, F. E. SCOTT, P. H. RHODES, B. H. NERREN, AND R. J. HARWELL

SURFACE-TENSION-INDUCED CONVECTION (MA-041)

R. E. REED, W. UELHOFF, AND H. L. ADAIR

MONOTECTIC AND SYNTECTIC ALLOYS (MA-044)

L. L. LACY AND C. Y. ANG

INTERFACE MARKING IN CRYSTALS (MA-060)

H. C. GATOS, A. F. WITT, M. LICHTENSTEIGER, AND C. J. HERMAN

ZERO-G PROCESSING OF MAGNETS (MA-070)

D. J. LARSON, JR.

CRYSTAL GROWTH FROM THE VAPOR PHASE (MA-085)

H. WIEDEMEIER, H. SADEEK, F. C. KLASSIG, M. NOREK, AND R. SANTANDREA

HALIDE EUTECTIC GROWTH (MA-131)

A. S. YUE, C. W. YEH, AND B. K. YUE

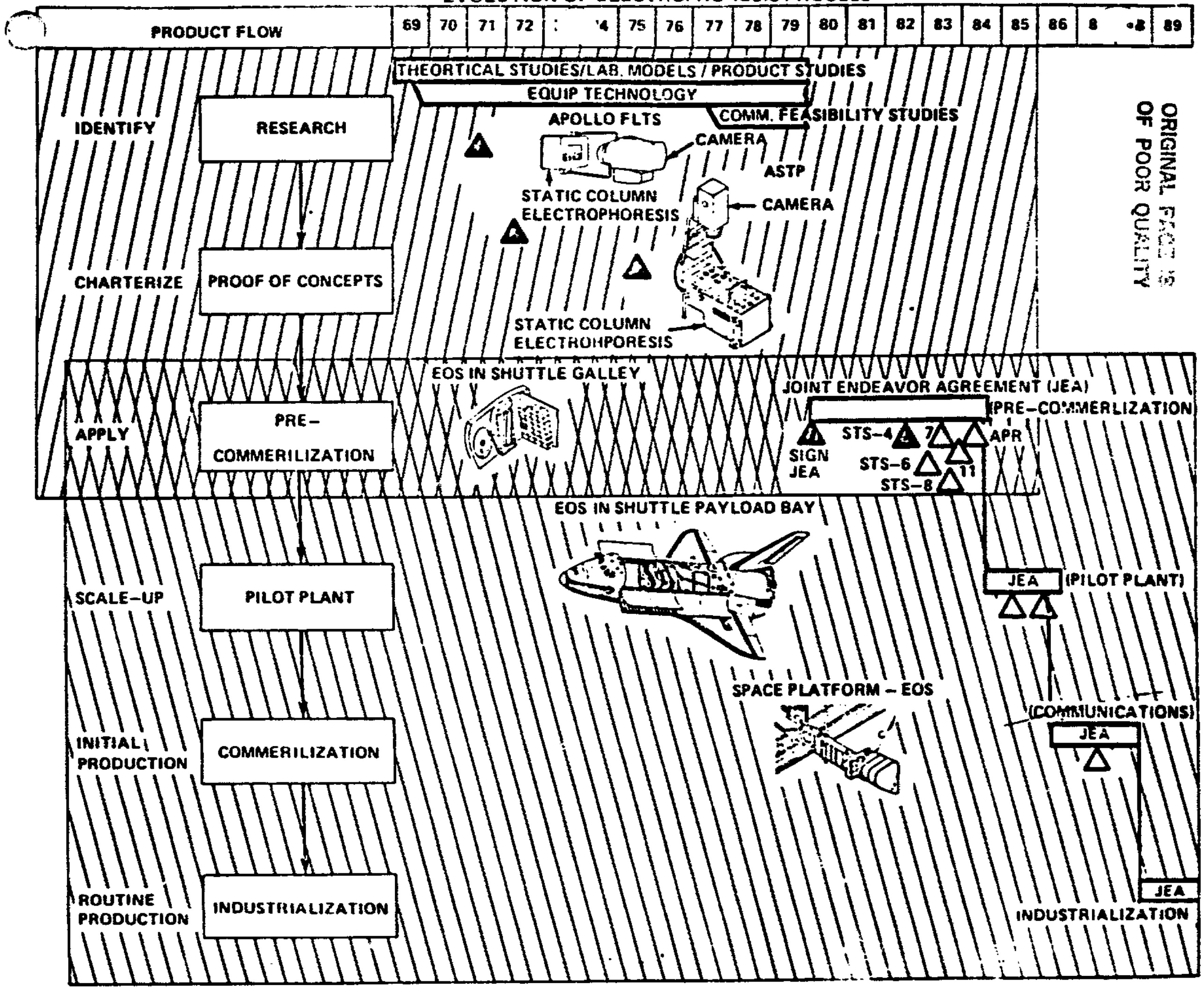
SHUTTLE EXPERIMENTS

MLR - STS 3, STS 4

EEVT - STS 3

CFES - STS 4

EVOLUTION OF ELECTROPHORESIS PROCESS



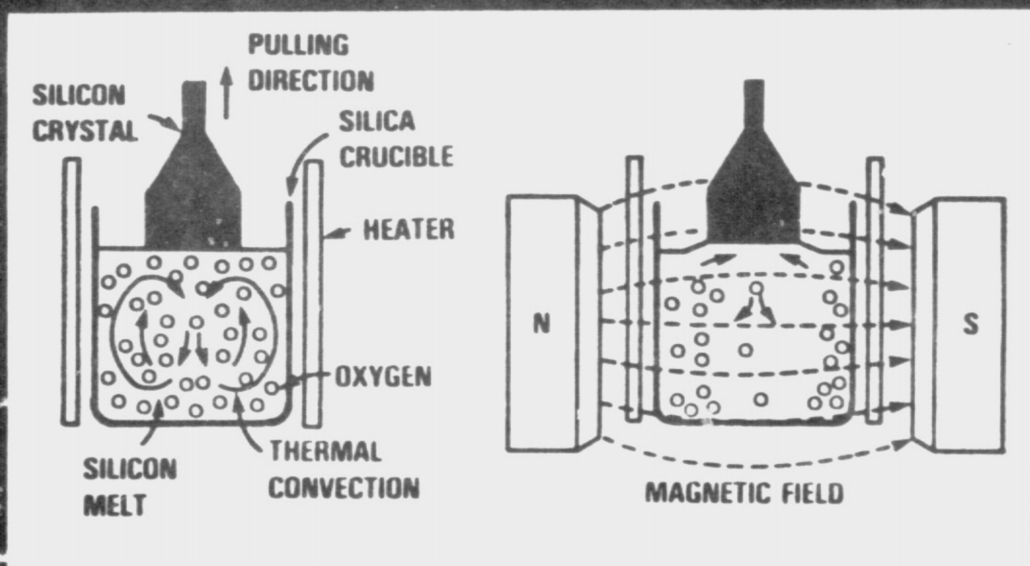
Electronics international

Significant developments in technology and business

Magnetic field breeds Skylab-like semiconductors

by Charles Cohen, Tokyo bureau manager

By eliminating convection currents in silicon melt, Sony enhances crystal uniformity, chip yields



MATERIALS PROCESSING IN SPACE EXPERIMENTS

- o MAJOR AREA OF CONCERN IN THE MATERIALS PROCESSING IN SPACE PROGRAM IS THE LONG TIME REQUIRED TO DO EXPERIMENTS

  - AVERAGE LENGTH OF TIME A MATERIALS SCIENTIST SPENDS ON A PROBLEM IS ABOUT THREE YEARS

- o USE OF A PERMANENT, MAN IN THE LOOP, LABORATORY (E.G., SALYUT) TO PERFORM MATERIALS PROCESSING IN SPACE EXPERIMENTS IN A STANDARD LABORATORY FASHION

SPACE STATION REQUIREMENTS

- o MAN IN LOOP
  - OBSERVATION
  - CHARACTERIZATION OF RESULTS (QUICK LOOK)
  - REPAIR
- o EASE AND FREQUENCY OF ACCESS
  - PROVIDE AND RETURN SAMPLES
  - EST. 1 MONTH REVISIT
- o HIGHER POWER/COOLING REQUIRED
  - EST. 10-25 KVA
  - NOT RESTRICTED TO SMALL SAMPLES
- o LONGER, NON-INTERRUPTED RUN TIME REQUIRED
  - EST. 30 DAYS FOR SOLUTION CRYSTAL GROWTH (TTF-TCNQ)
  - EST. 20-30 DAYS FOR INFRARED DETECTOR (BRIDGEMAN GROWTH OF HgCdTe)
- o COMMERCIAL PROBABLY AUTOMATED
  - MAN REQUIRED PROBABLY ONLY FOR INITIAL CHECKOUT AND SERVICING
  - EVOLUTION FROM MANNED STATION
- o G-LEVELS
  - $< 10^{-3}$ G
  - G JITTER LEVELS - TBD
  - PROBABLY REQUIRE JITTER FREE, LOW LEVELS FOR COMMERCIAL VENTURES
- o DATA TRANSMISSIONS
  - VIDEO

MPS PROC..S TH...

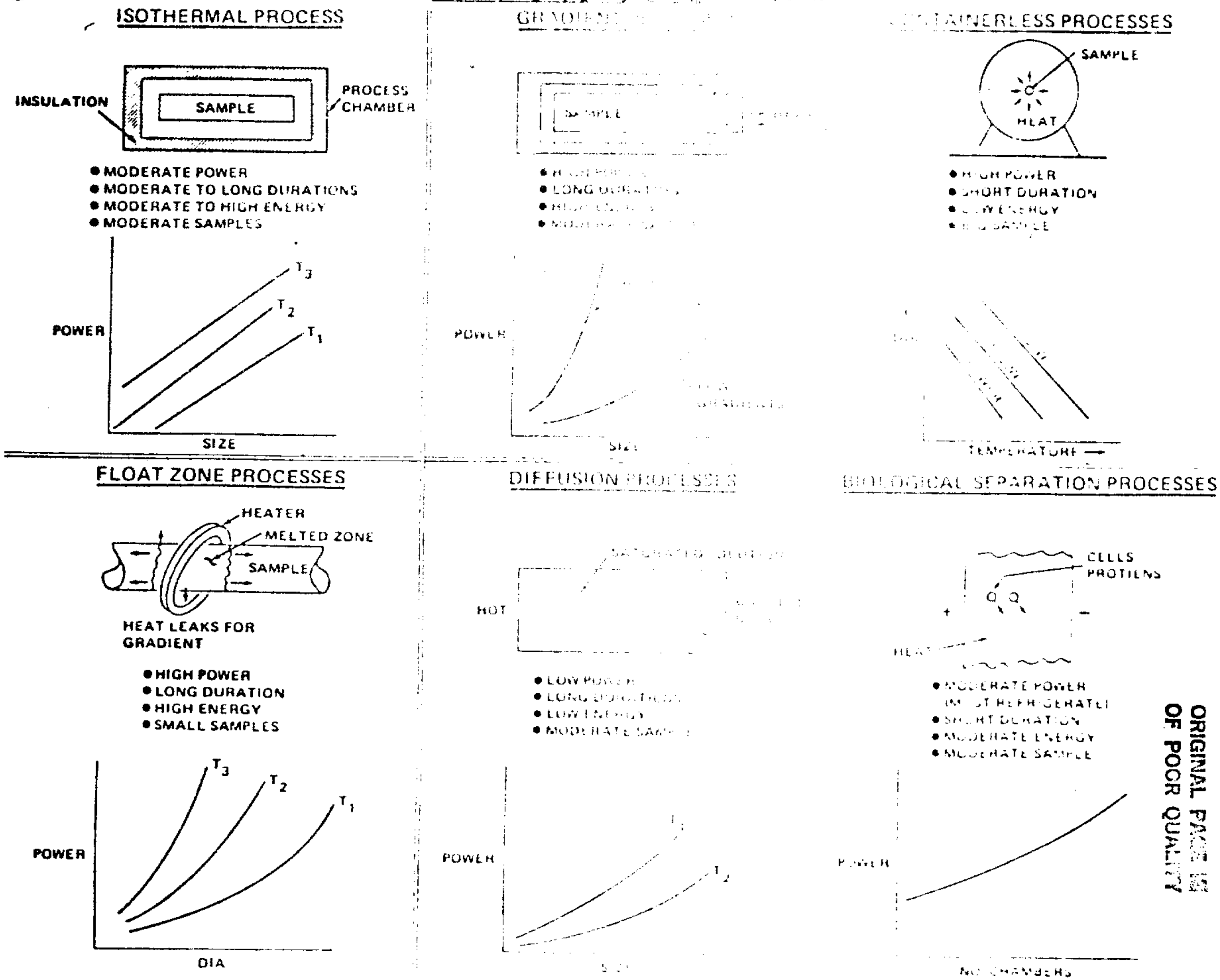


FIGURE 3

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MPS RESEARCH AREAS

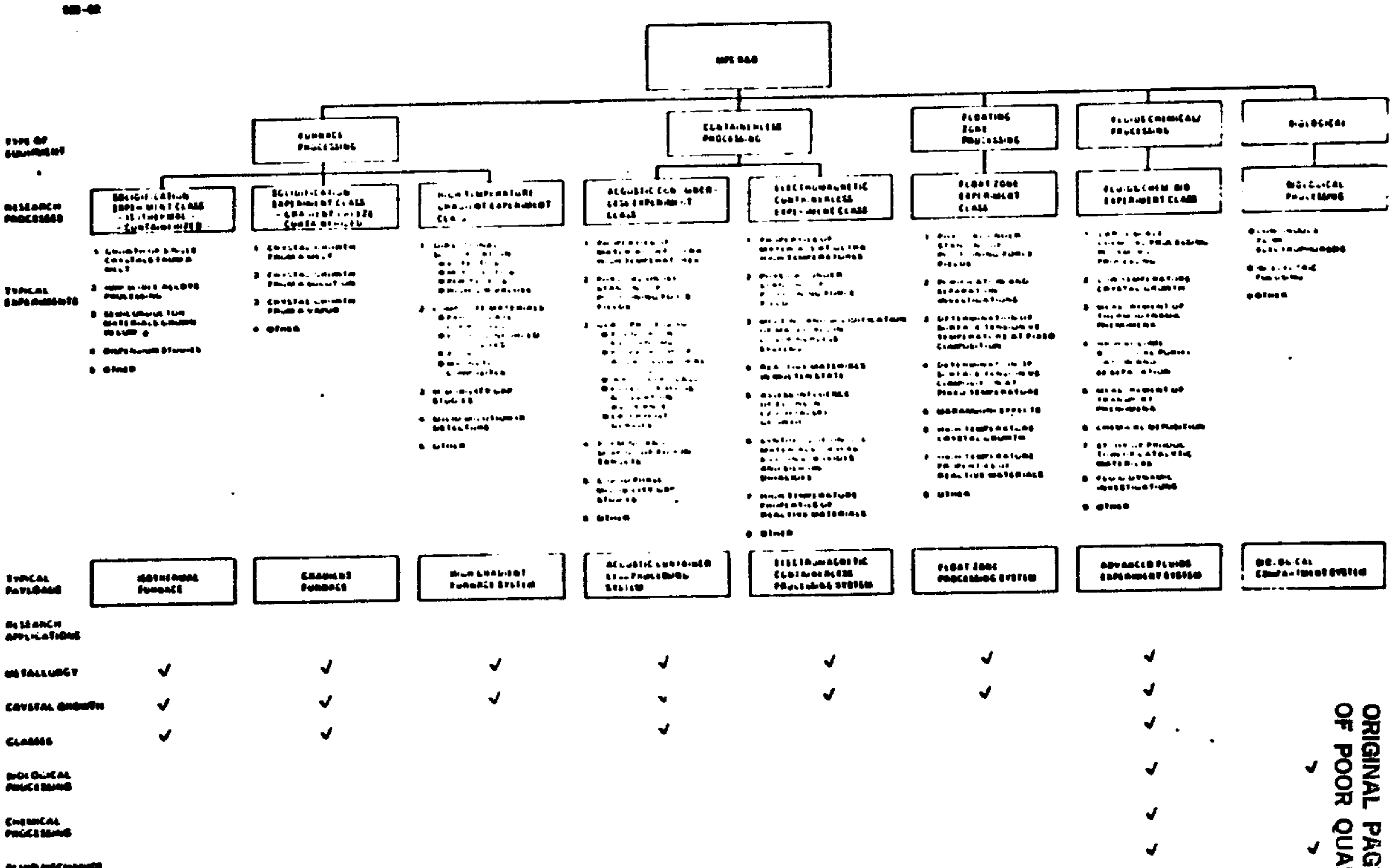

FIGURE 7

FOREIGN MATERIALS PROCESSING PROGRAMS

COUNTRY/MISSION	DESCRIPTION	LEVEL OF EFFORT	STATUS
Germany/D-1	Dedicated Spacelab mission with primary emphasis on low gravity crystal growth, metallurgy, fluids, and chemical processing experiments.	15.36M overall programs	Sept. 1984 STS launch
Germany/SSCP	24 Small Self-Contained Payloads	varies	STS launches on space available basis
Germany/TEXUS	Cooperative sounding rocket program with Sweden for low-g exper.	Phased-in ESA management of national program by 1982	1-2 rockets launches per year
Germany/SPAS-01	Commercial materials processing facility to fly on STS reimbursably		ESA signed 6/81 Feb. 1983 STS Launch
ESA/Ground Research Activities	Research in fluids, chem. processes, alloy and composite formation and electronic materials		
ESA Spacelab I	Experiments include crystal growth, solidification, fluid dynamics on the Fluid Physics Module, and chemical processing.	35 experiments from 9 member states	1982 launch

Country/Mission	Description	Level of Effort	Status
ESA/Microgravity Research	Progr[illegible]'s initial emp[illegible] to [illegible]velopment of multi-user [illegible] for [illegible], [illegible] quality [illegible].	37M 1981-85	Recently established program
France/U.S. Cooperation	[illegible] metal alloy solid[illegible]ation.		Definition study for potential STS flight
	[illegible] flight of [illegible] with exper.		LSA currently being negotiated
Japan/Sub-orbital launch tests	[illegible] sounding rocket program.		Last two launches have failed, producing no data.
Japan/First Material Processing test	[illegible] discussing a dedicated Spacelab Mission.		Approx. 1986 launch.
USSR/Salyut 6	Research in potential for zero-g processing of semi conductor crystals, fiber optic, metal alloys, and structural materials using crystal. alloy and evaporator furnaces.	Unknown	Not currently conducting materials processing exper.

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I-A SPACE STATION BIBLIOGRAPHIES

1. Repository Index of Space Station Reports, File 003, Documentation Repository, Marshall Space Flight Center, July 1982.

   This index is an inventory of about 600 reports, procedures, manuals and other documents which are applicable to the Space Station program. The inclusive dates are 1963 to the present.

2. Repository Index of 25 kW Power System Reports, File 020, Documentation Repository, Marshall Space Flight Center, July 1982.

   This index is an inventory of about 50 reports, procedures, manuals, and other documents related to the Space Platform program. Most of the reports are under the title "25 kW Module" which is the program from which the Space Platform concept evolved.

I-B MANNED SPACE STATION STUDIES

1. Space Station, Executive Summary, McDonnell Douglas Astronautics Company, Report No. MDC G0639, Contract No. NAS8-25140, August 1970.

   This study was a Phase B definition of the Space Station as a long-lasting, general-purpose facility in Earth orbit. The initial guidelines stipulated a crew size of 12, use of the first and second stages of Saturn V for launch and a 1977 launch date. The study also included partial Phase A investigations of: an Initial Logistics System, the operations of an Advanced Logistics System, a Space Base (for a crew of 50), and a Planetary Mission Module.

2. Space Station, Executive Summary, McDonnell Douglas Astronautics Company, Report No. MDC G2727, Contract No. NAS8-25140, April 1972.

   This study was performed under the Space Station Phase B Extension Period for the Phase B definition of a Modular Space Station. The modular approach, characterized by low initial cost and incremental manning, utilizes the Space Shuttle for module delivery and on-orbit logistics support. The Modular Space Station design includes a general purpose laboratory to provide support equipment and space for research work. The system has the capability to grow from a 2-man to a 12-man facility.

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I-B MANNED SPACE STATION STUDIES (CONT.)

3. MSFC Skylab Mission Report - Saturn Workshop, NASA TM X-64814, Marshall Space Flight Center, October 1974.

> The document is a review of the Skylab's Saturn Workshop mission performance. It includes a survey of the variety of experiments conducted during the mission. Also included is a comparison of the station's performance as compared with design parameters, and a discussion of problem causes and solutions.

4. Manned Orbital Systems Concepts Study, Book 1 - Executive Summary, McDonnell Douglas Astronautics Company, Report No. MDC G5919, Contract No. NAS8-31014, September 1975.

> The MOSC study encompassed a 9-month effort which examined the requirements for, and established the definition of, a cost-effective orbital facility capable of supporting extended manned operations in Earth orbit. In Task 1, "Requirements Derivation", payload and mission requirements were examined for manned orbital systems with operational capabilities beyond those of the Shuttle/Spacelab program.

5. Space Station Systems Analysis Study, Final Report - Executive Summary, Grumman Aerospace, Report No. NSS-SS-RP022, Contract No. NAS8-31993, July 1977.

> This was a 16-month study of projected manned activities in space during the 1980s and 1990s, capitalizing on the Space Shuttle and its capabiltiy for routine space operations. The executive summary includes an overview of the entire study program with emphasis on the later work dealing with Space Construction Base activity.

6. Skylab, Our First Space Station, NASA Special Publication 400, prepared by Marshall Space Flight Center, Leland F. Belew, editor, 1977.

> This book describes the Skylab space station design and missions. Also included are discussions of the successful "rendezvous and repair" effort, and of the Skylab ground-space partnership.

7. Science and Applications Manned Space Platform - A Conceptual Design and Analysis Study, prepared by Program Development, NASA/Marshall Space Flight Center, October 1981.

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I-B MANNED SPACE STUDIES (CONT.)

This is a MSFC in-house study of a Science and Applications Manned Space Platform (SAMSP) to provide a permanent low earth orbit manned capability for the late 1980s. The study is based on the utilization of existing/planned hardware such as Spacelab, Shuttle, and the 25 kW (or 12.5 kW) Power System.

8. Evolutionary Science and Applications Space Platform (Characterization of Concepts), McDonnell Douglas Astronautics Company, Report No. MDCG9766, Contract No. NAS8-33592, February 1982.

This two-fold study evaluated and selected concepts for evolving a Space Station in conjunction with the Space Platform, a permanently manned presence in space - early, with a maximum of existing technology. The schedule calls for selected science, applications, and technology payloads in orbit by 1989, plus growth to support major operational missions, on-site and in remote orbits, by 1995.

9. Evolutionary Space Platform Concept Study, Volume I - Exeutive Summary, , McDonnell Douglas Astronautics Company, Report No. MDC H0072, Contract No. NAS8-33592, May 1982.

This study encompasses a 10-month effort to define, evaluate and compare approaches and concepts for evolving unmanned and manned capability platforms to establish a permanent presence in space. Tasks included the analysis of requirements for a manned space platform, identifying alternate concepts, and performing system analysis.

I-C UNMANNED SPACE STATION STUDIES

1. 25 kW Power Module Evolution Study, Lockheed Missiles and Space Company, Report No. LMSC-D614921A, Contract No. NAS8-32928, August 1978.

In Part I this study developed payload application summaries and time-phased payload requirements, for the time period 1983 through the 1990s, based upon NASA future planning. In the Parts II and III the study developed conceptual definitions for the power module required to support the payload requirements defined in Part I.

I-C UNMANNED SPACE STATION STUDIES (CONT.)

2. 25 kW Power Module Evolution Study, Lockheed Missiles and Space Company, Report No. LMSC-D614949, Contract No. NAS8-32928, February 1979.

> This study defined evolutionary growth paths to 100 kW, and above, for the MSFC 25 kW Power Module. The tasks included payload requirements analysis, evolutionary systems definition and recommended program definition. The guidelines included an October 1983 IOC with evolutionary growth to meet multi-orbit payload requirements through 1990.

3. 25 kW Power System Reference Concepts, Report No. PM-001, Program Development Preliminary Design Office, Marshall Space Flight Center, September 1979.

> This in-house MSFC study defined a "typical" 25 kW Power System to be used as a reference point for any other studies or activities requiring a 25 kW Power System design definition. It was from this reference study that the Space Platform (SP) concept evolved. Most of the SP Phase B Study documents are not available because of the A-109 restrictions of the competitive studies by McDonnell Douglas Astronautics Corporation and TRW.

4. Geostationary Platform Feasibility Study, Volume I: Executive Summary and Volume II: Technical Presentation, The Aerospace Corporation, Report No. ATR-79(7749)-1, Vol. I and Vol. II, Contract No. NAS8-32881, September 1979.

> This study addresses the concept of large platforms supporting multipurpose communications payloads to exploit economy of scale, reduce congestion in the geostationary orbit, provide interconnectivity between diverse earth stations, and obtain significant frequency re-use with large multibeam antennas. Emphasis is on communication payload issues, performance requirements, and tradeoffs for future US domestic systems. Other candidate payloads and experiments are also examined.

5. Geostationary Platform System Concepts Definition Follow-on Study, Final Report, Volume IIA - Technical Task 11 (LSST Special Emphasis), General Dynamics Convair Division and Comsat, Report No. GDC-GPP-79-010 (IIA), Contract No. NAS8-33527, September 1980.

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UNMANNED SPACE STATION STUDIES (CONT.)

This study, a follow-on to the initial Geostationary Platform Phase A study, concentrated on an analysis of structural requirements deriving from the Phase A. The concepts studied ranged from packaged platforms less than half a Shuttle cargo-bay length to full cargo-bay length.

6. Conceptual Design Study - Science and Applications Space Platform (SASP), Volume I - Executive Summary and Volume II - Technical Report, McDonnell Douglas Astronautics Company, Report No. MDC G9246, Contract No. NAS8-33592 October 1980.

This is a one-year Phase A concept study of a low earth orbit platform, attached to a Power System, designed to provide accomodations for a variety of science and applications payloads. The platform configuration conceived in this study consists of a two part evolution: the First Order Platform consists of minor appendages to the Power System, whereas the Second Order Platform is designed to accommodate more and larger payloads.

7. Geostationary Platform Systems Concepts Definition Follow-on Study, Final Report, Volume 1 - Executive Summary, Volume IB - Technical Tasks 8 & 9, General Dynamics Convair Division and Comsat, Report No. GDC-GPP-79-010(1), Contract No. NAS8-33527, September 1981.

This study, a follow-on to the 1979 Phase A Concepts Definition Study for the Geostationary Platform, further defined technology requirements, configuration, and communications architecture of operational platforms and developed a preliminary definition of an experimental platform. Task 8 is an update of the Operational Platforms Study and Task 9 is analysis and definition of an experimental platform.

8. Space Platform/Power System Executive Summary, Alternate System Design Concept Study, McDonnell Douglas Astronautics Company, Report No. MDC H0108, Contract No. NAS8-33955, July 1982.

This is a summary (with A-109 sensitive material removed) of the MDAC Space Platform design which evolved from the 25 kW Power Module/Power System Platform/Space Platform Phase B study. The system includes berthing ports for exchange of science/applications payloads on-orbit.

9. Alternative System Design Concept Study of the 25 kW Power System, TRW, Report No. 34444.000-004, Contract No. NAS8-33956, June 1982.

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OTHER REFERENCES

Marshall, W. R., et al., "A Focus for Space Industrialization," Nineteenth Space Congress, April 1982.

Taylor, K. R.; Waltz, D. M.; and, Meissinger, H. F., "Materials Experiment Carrier, An Approach to Expanded Space Processing Capability," Paper 80-2[illegible]9, 1980 Meeting of American Astronautical Society, October 20, 1980.

"Materials Experiment Carrier Concept Definition Study," Volumes I and II, TRW Defense and Space Systems Group, Report MFS.6-81-[illegible], NASA Contract NAS8-33688, December 1981.

"Requirements and Concepts for Materials Science and Manufacturing in Space Payload Equipment Study," all volumes, TRW Systems Group, NASA Contract NAS8-28938, June 1973.

Taylor, K. R., "Requirements and Resources for Materials Processing in Space," AIAA Conference on Large Space Platforms, September 197[illegible].

"Materials Experiment Carrier - Concepts Definition Study," Part 2, Volume I - Executive Summary, and Volume II - Technical Report, TRW, Reports No. MFS.6-81-221 and MFS.6-81-222, Contract No. NAS8-33688, December 1981.

Spacelab Payload Program — An Update and Projection

Spacelab Current Status

- Two Missions Completed
  - OSS-1
  - OSTA-1
- Increased STS System Understanding
- Some Mid-Deck Experience
- Spacelab-1 in Integration Phase at KSC

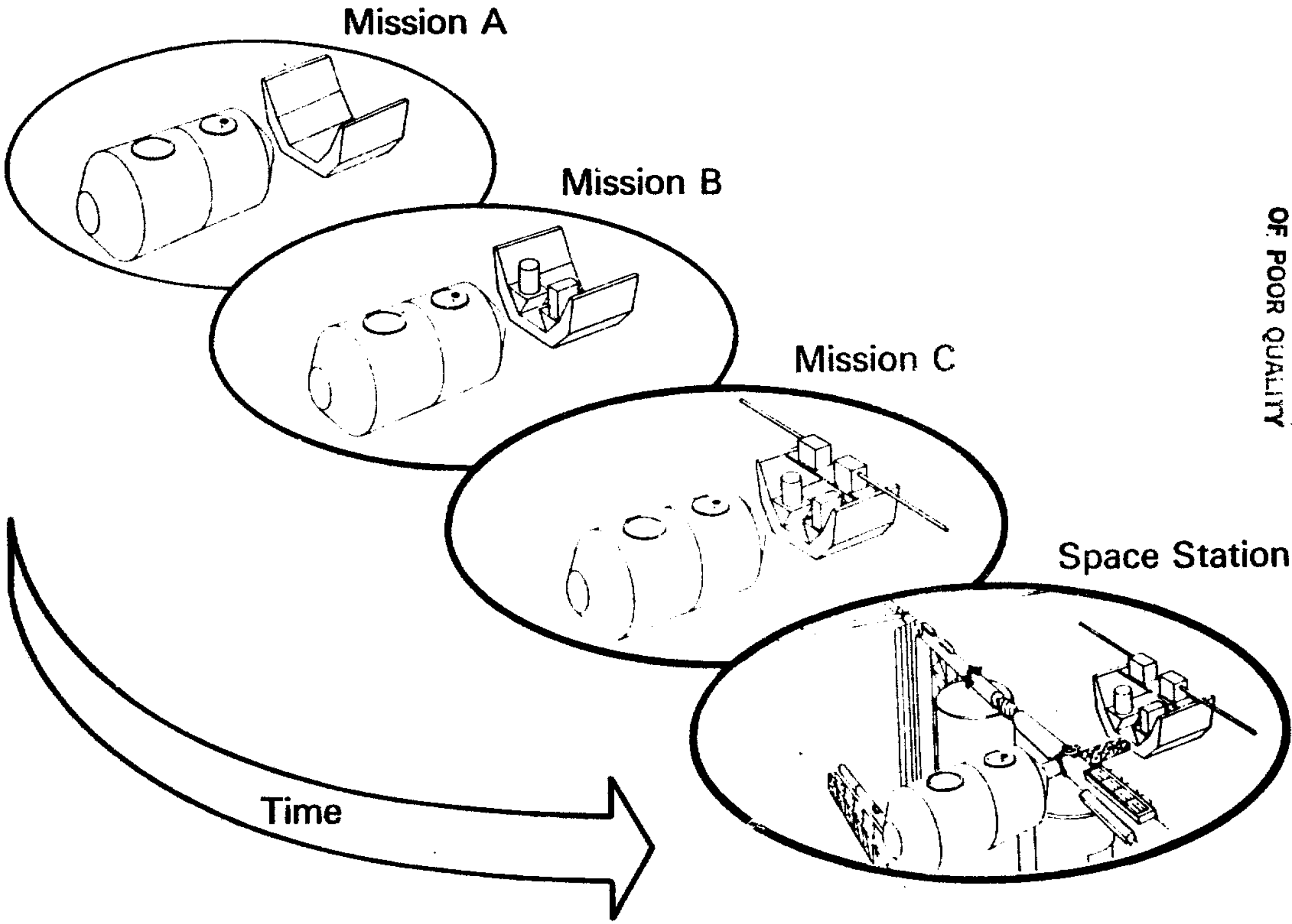
Projection

- Reflights Are a Key to Reducing Costs
- Single Discipline Labs
- Space Station Goal

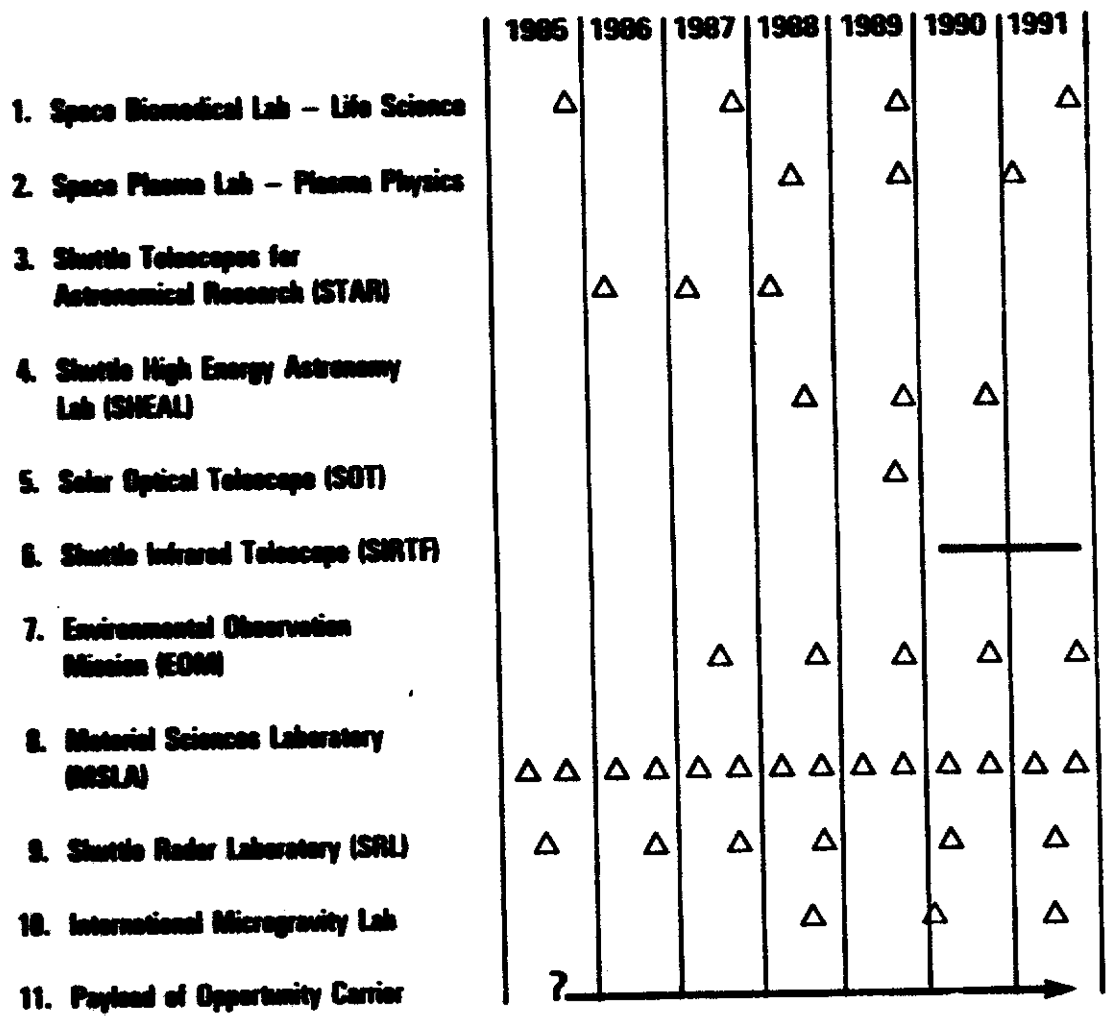
Discipline Lab Concept

- Single/Compatible Disciplines
- Related/Integrated Instrument Sets
- Mission to Mission Evolution
- Establish Modular Instruments
- Maintain Margins
- Do Not Deintegrate

Discipline Laboratory Evolution



Discipline Laboratory Overview



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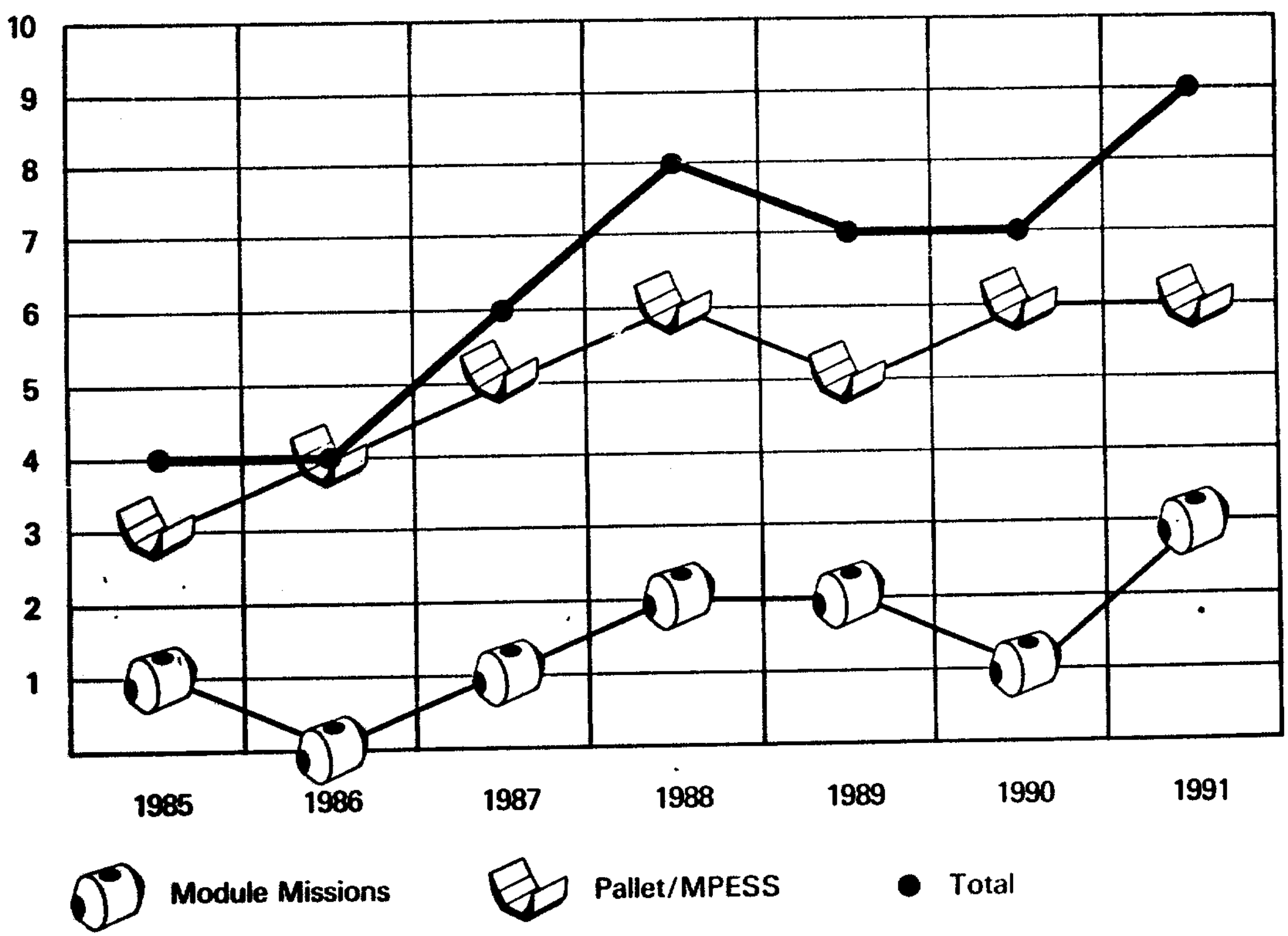
Discipline Laboratories – Flight Model/Aug. 1982



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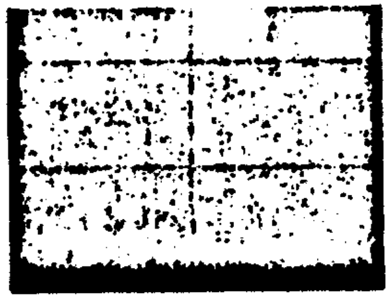
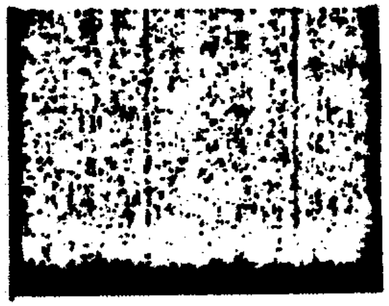
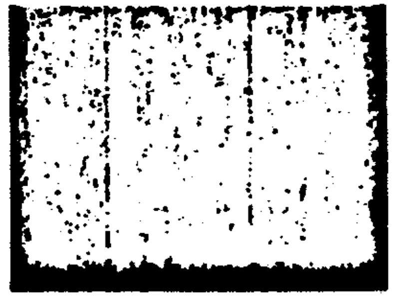
Discipline Laboratories



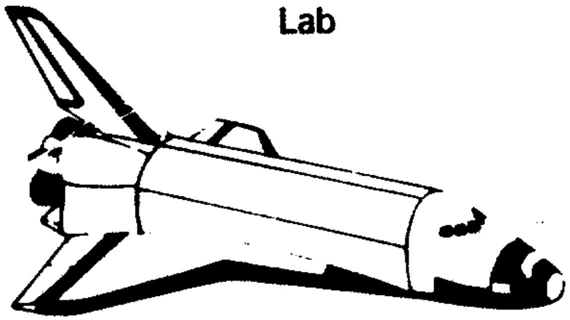
International Microgravity Lab

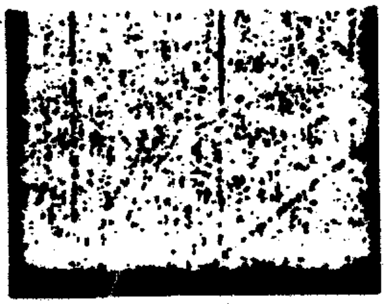


Materials Science Lab

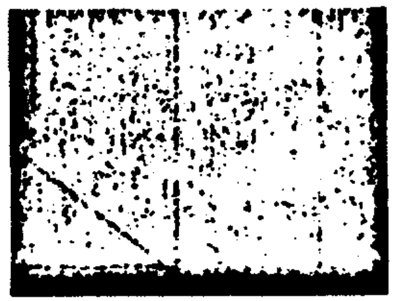


Earth Observation Mission

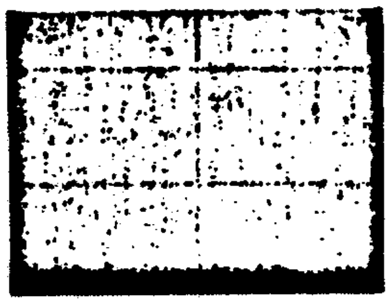




Space Biomedical Lab

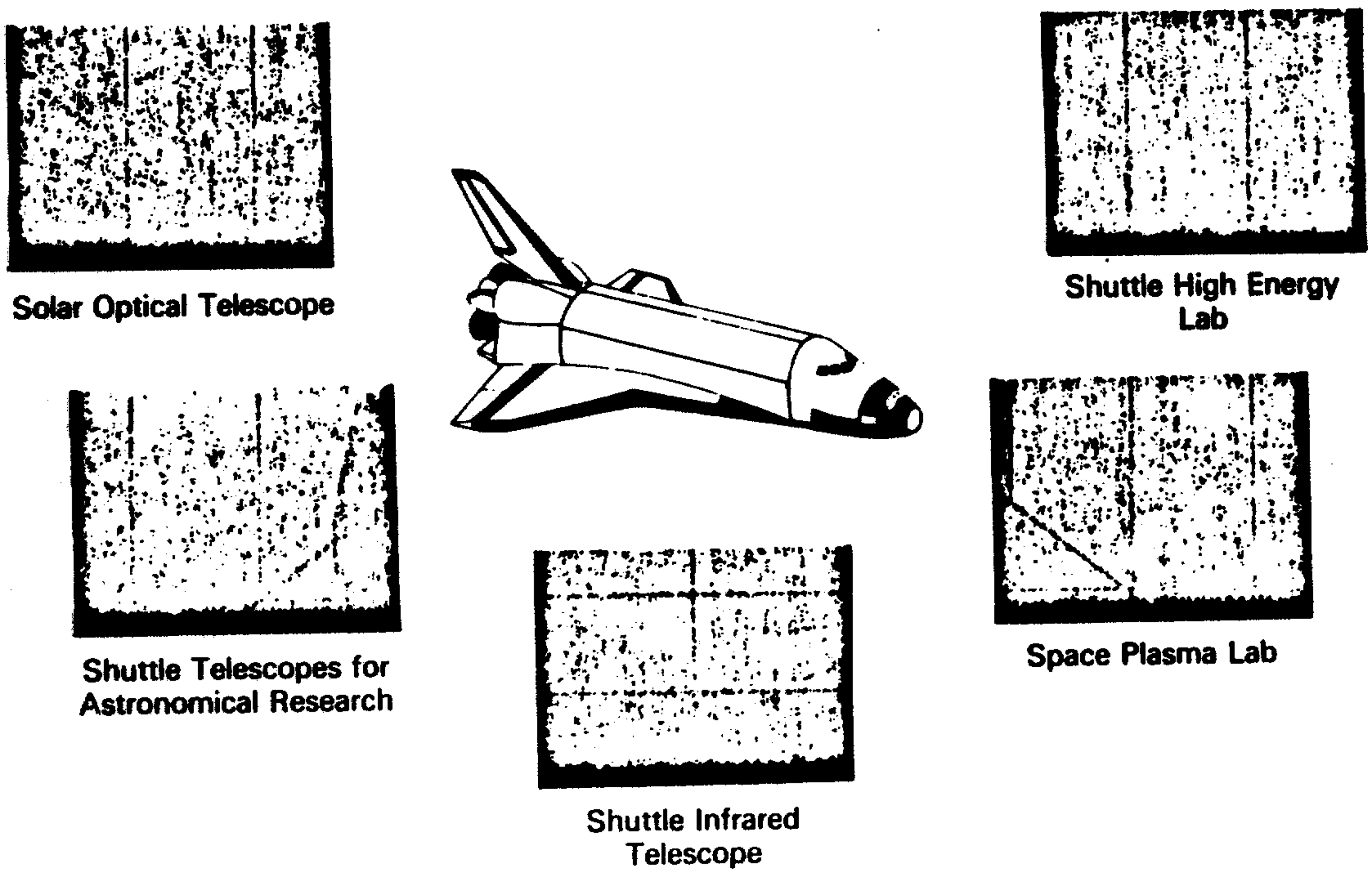


Payload of Opportunity Carrier

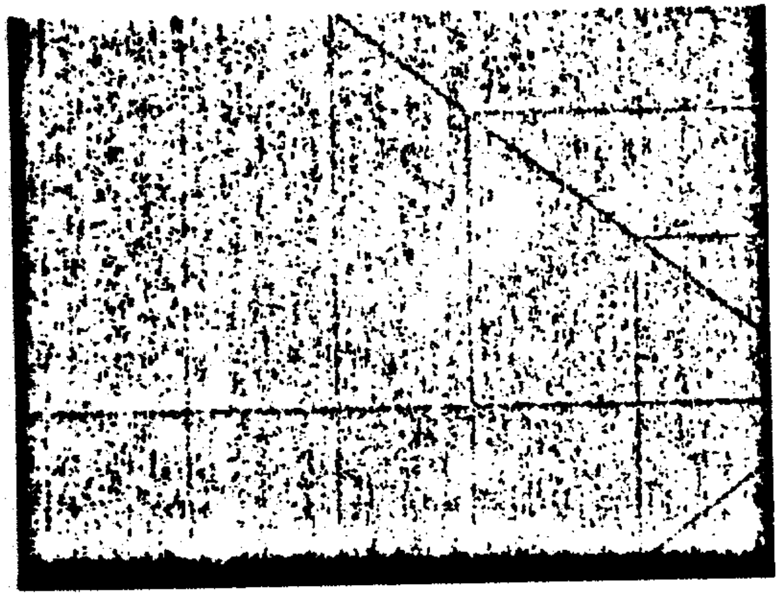


Shuttle Radar Lab

Discipline Laboratories



Space Biomedical Laboratory (SL-4, 10)



First Launch: Nov. 1985

Flight Interval: 24 Months

No. of Experiments: 25

P.I. Status: Selected for Definition

Configuration: Long Module

Hardware Status: In Development

Major Facilities or Instruments:
- Research Animal Holding Facility
- General Purpose Work Station
- Physiological Monitoring System
- Refrigerators-Freezer

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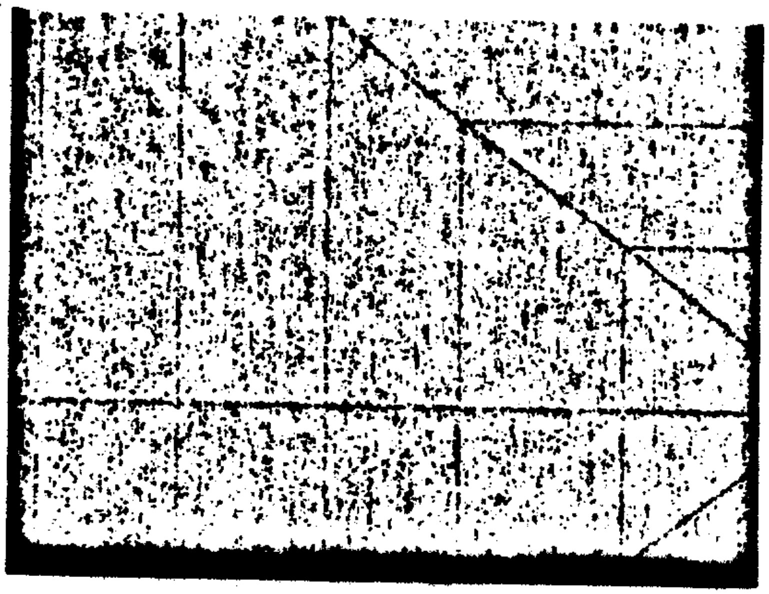
Goals/Objectives

- To Conduct a Comprehensive and Integrated Exploration of the Effects of Acute Weightlessness on Living Systems

Space Plasma Lab



First Launch: Dec. 1987

Flight Interval: 18 Months

No. of Experiments: 8

P.I. Status: Selected for Definition

Configuration: Short Module and 2 Pallets

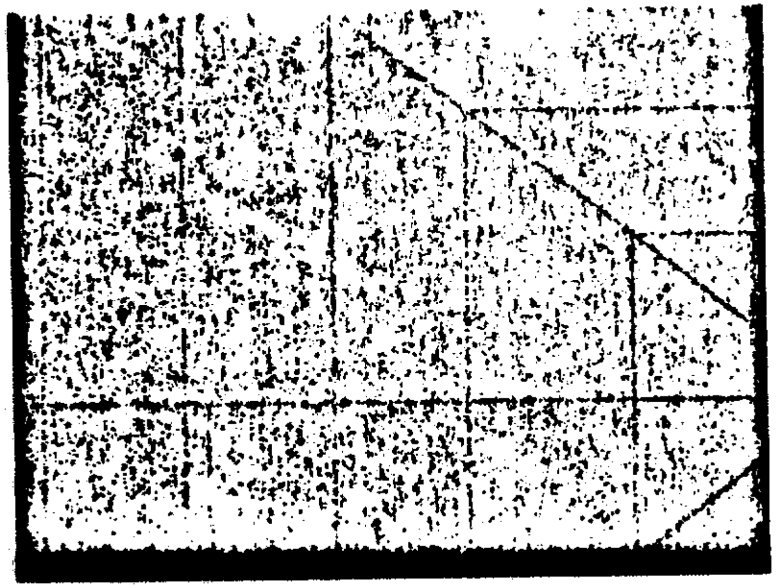
Hardware Status: Definition

Major Facilities or Instruments:
- Waves in Space Plasma
- Space Experiments with Particle Accelerators
- Recoverable Plasma Diagnostic Package
- Theoretical Experiments in Beam Plasma Physics

Goals Objectives

- Perform Active Experiments in Plasma Physics Using the Earth's Magnetosphere as a Laboratory

Solar Optical Telescope

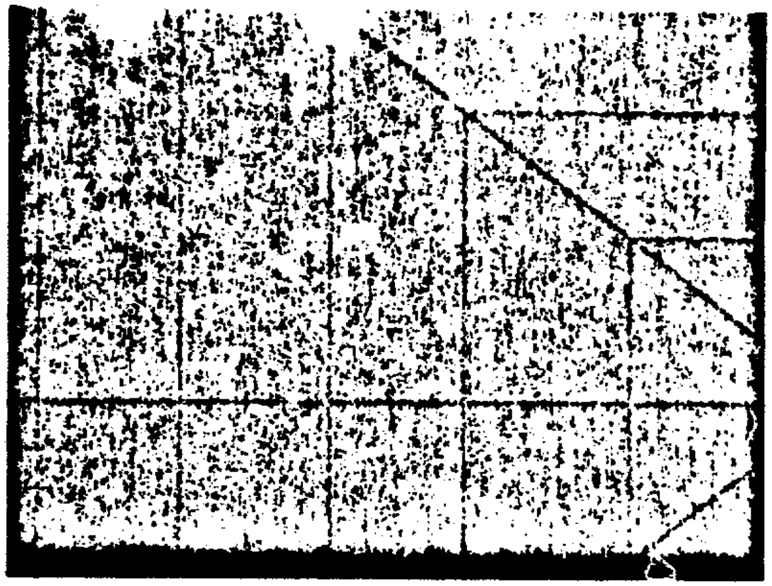


First Launch:	October 1989
Flight Interval:	Approx. 12 Months
No. of Experiments:	2 (Initial)
P.I. Status:	Phase B Development
Configuration:	Dedicated Mission (Igloo, Pointer + 1 or 2 Pallets)
Hardware Status:	Development Phase
Major Facilities or Instruments:	— Telescope Facility (1.25m Primary with 0.1 Arc Second Resolution) — Coordinated Filtergraph Spectrograph (Dr. Title) — Photometric Filtergraph (Dr. Zirin)

Goals/Objectives

- Origin and Evolution of the Solar Magnetic Field
- Heating of the Chromosphere and Transition Region
- Mass Transport in the Lower Solar Atmosphere
- Small Scale Solar Flare Processes

Material Science Laboratory



First Launch: April 1984

Flight Interval: 6 Months

No. of Experiments: Variable

P.I. Status: Selected

Configuration: MPESS

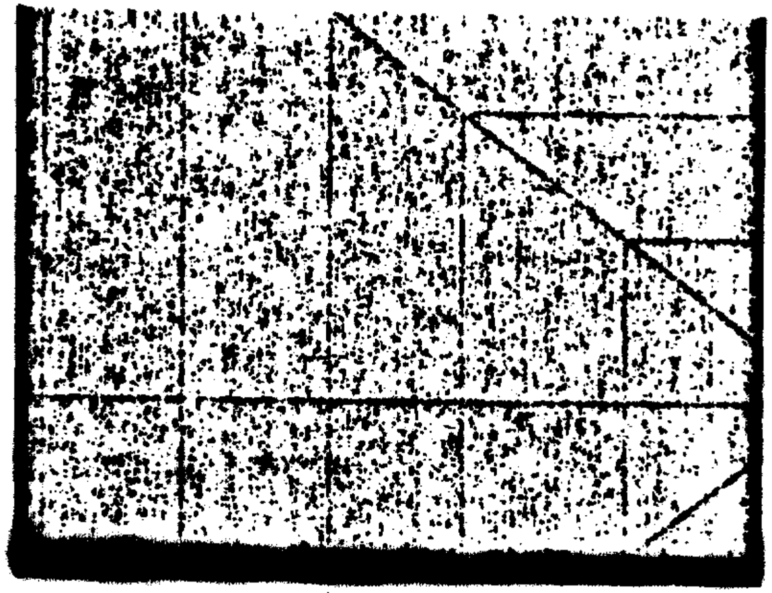
Hardware Status: In Development

Major Facilities or Instruments: — Materials Experiment Assembly

Goals/Objectives

- Materials Processing Demonstration in Low g Environment

Shuttle Radar Laboratory



First Launch: August 1984

Flight Interval: 12 to 18 Months

No. of Experiments: 4

P.I. Status: Selected

Configuration: Pallet

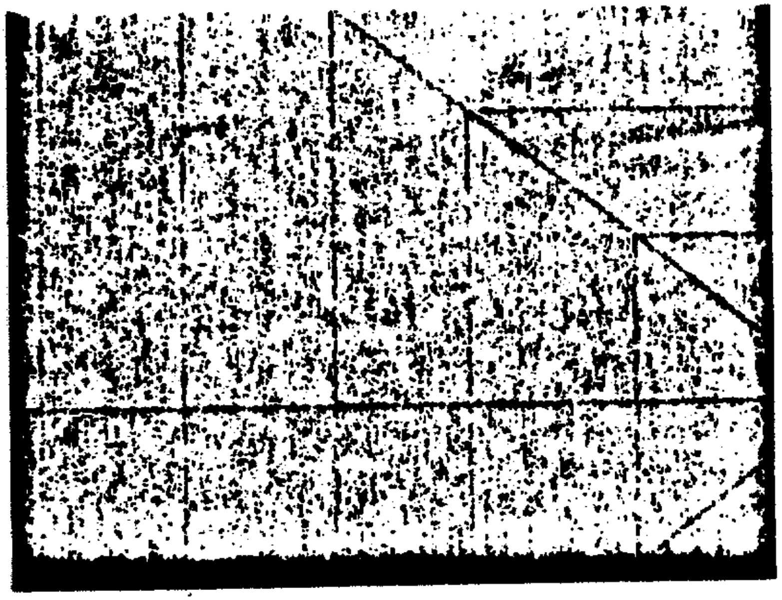
Hardware Status: Development

Major Facilities or Instruments:
- Shuttle Imaging Radar
- Large Format Camera
- Measurement of Air Pollution from Satellites

Goals/Objectives

- Evaluate Spaceborne Imaging Radars for Geological Exploration
- Obtain High Resolution Photographs for Geological and Cartographical Applications
- Measure the Global Distribution of Carbon Monoxide in the Troposphere

Shuttle Infrared Telescope



First Launch: 1990

Flight Interval: 12 to 18 Months

No. of Experiments: $\leqslant 3$

P.I. Status: Pre A.O.

Configuration: Dedicated (Pallet + Igloo + IPS)

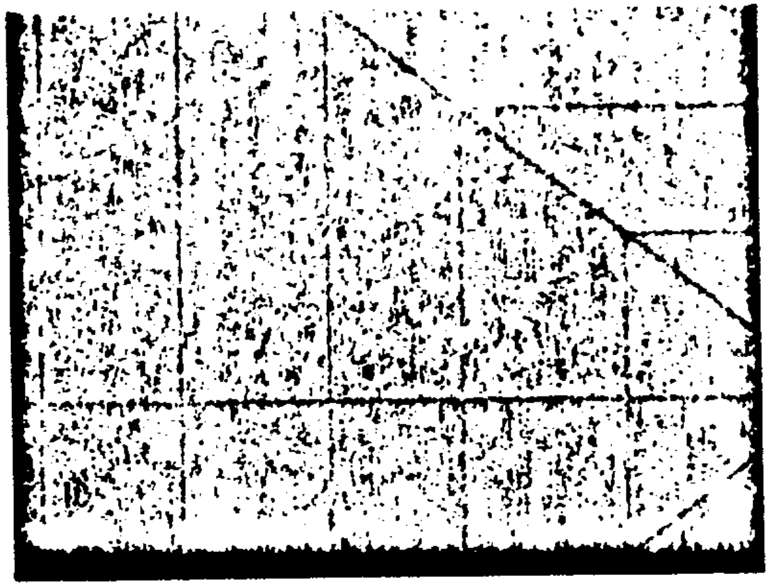
Hardware Status: Pre Phase B

Major Facilities or Instruments:
- 0.8m Cryogenically Coded Telescope with Up to Three Focal Plane Instruments

Goals/Objectives

- Study the Very Cold Regions of Space Where Cosmic Dust and Gas Condense into Stars
- Study Cool Solar System Objects
- Study Infrared-Emitting Extragalactic Objects

Environmental Observation Mission



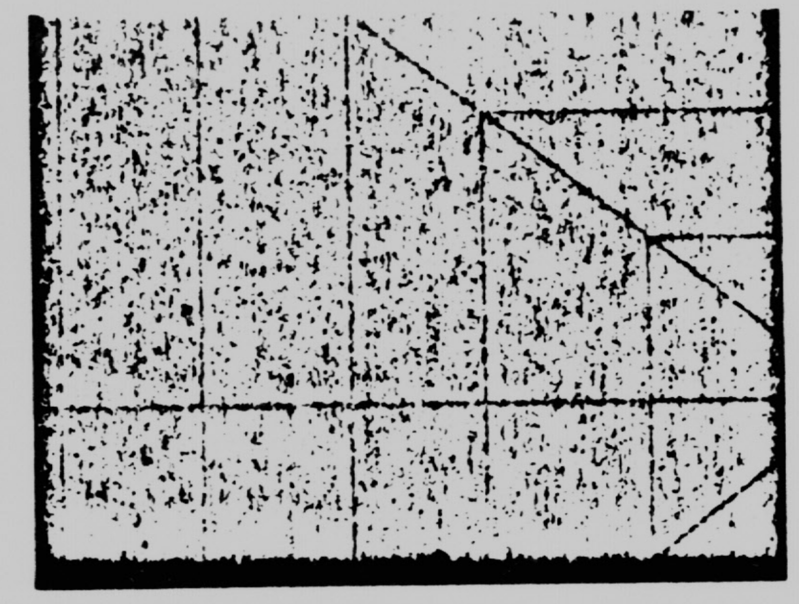
C-3

Goals/Objectives

- Determination of the Long Term Variability of the Solar Output
- Identification and Measurement of the Abundance of Upper Atmosphere Constituents

First Launch:	July 1986
Flight Interval:	12 Months
No. of Experiments:	6
P.I. Status:	Selected
Configuration:	Pallet + Igloo
Hardware Status:	In Development
Major Facilities or Instruments:	— Solar Irradiance Monitoring System — Atmospheric Trace Molecule Observation Through Spectroscopy — Imaging Spectroscopy Observation

International Microgravity Laboratory

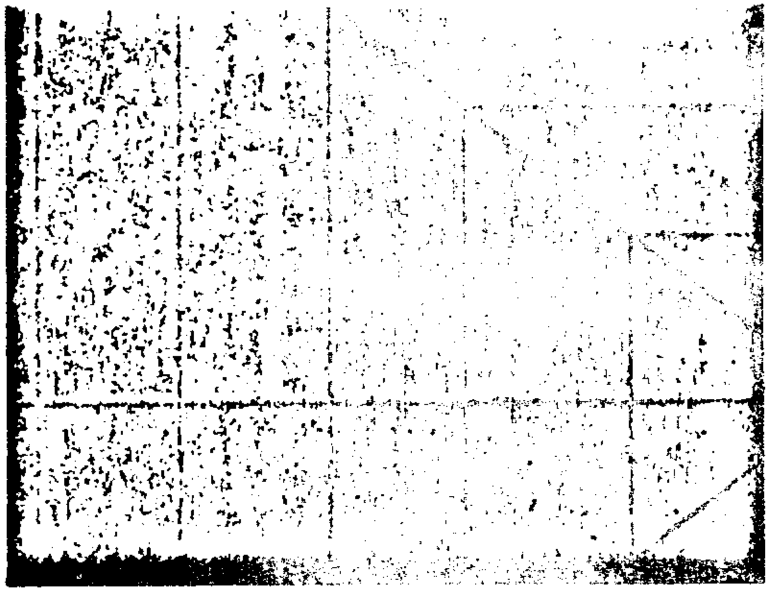


Goals/Objectives

- Low g Mission with Emphasis on Materials Processing and Life Sciences

First Launch:	1987
Flight Interval:	12 Months
No. of Experiments:	September 1982 Meetings to Identify Candidate Facilities
Status:	— Proposed in Sander/Bignier/Greger Discussions — In Discussion Stage with Pederson/Abrahamson/Edelson — Focus During Bignier Visit October 1982
Candidate Facilities and Instruments:	— Biorack — Material Science* Double Rack — Sled — FES/VCG — GFFC — DDM

Shuttle Telescopes for Astronomical Research

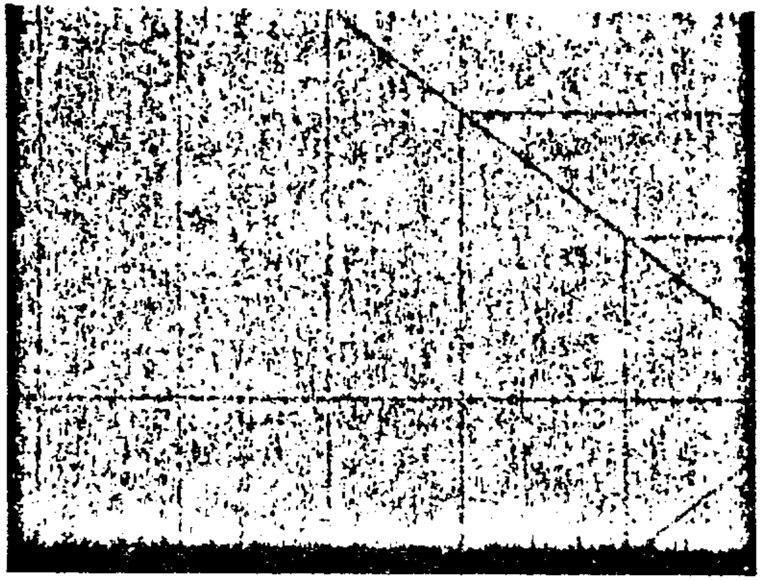


First Launch:	November 1985
Flight Interval:	12 Months
No. of Experiments:	3
P.I. Status:	Selected, Guest Investigator Program Planned
Configuration:	2 Pallets, Igloo and Pointer
Hardware Status:	In Development
Major Facilities or Instruments:	— Three Complementary Ultraviolet Telescopes with Spectrophotometry, Spectropolarimetry, and Imaging Capabilities

Goals/Objectives

- Ultraviolet Study of Hot Stars, Non Thermal Sources, Galactic Nuclei, Quasars, Interstellar Gas and Dust, and Targets of Opportunity

Shuttle High Energy Astrophysical Laboratory



Goals/Objectives

- Survey Low Energy Diffuse X-Rays from Interstellar Gases
- Observe Cosmic X-Ray Sources
- Measure Cosmic Ray Energy/Charge Spectra

First Launch:	1988
Flight Interval:	12 Months
No. of Experiments:	4
P.I. Status:	In Definition
Configuration:	Pallet + Igloo + 2 Unique Structures
Hardware Status:	In Definition
Major Facilities or Instruments:	— Large Area Modular Array of Reflectors — Diffuse X-Ray Spectrometer — Broad Band X-Ray Telescope — Cosmic Ray Nuclei Experiment

Summary

- Leads Toward Space Station/Long Term Orbital Studies
- Provide Opportunities for Growth
- Provides Opportunities for Flight in This Decade
- Maintains Science Teams' Interest During Free Flyer Lull

SPACE STATION PROGRAM DEFINITION

TECHNOLOGY DEVELOPMENT MISSIONS

PRESENTED AT
CONTRACTOR ORIENTATION BRIEFING
SEPTEMBER 14-15, 1982

NASA HEADQUARTERS

WASHINGTON, D.C.

S. V. MANSON
NASA HQ
RSS-5

SPACE STATION PROGRAM DEFINITION

CONTRACTOR ORIENTATION BRIEFING
SEPTEMBER 14-15, 1982

TECHNOLOGY DEVELOPMENT (TD) MISSIONS

CONTENTS

INTRODUCTION

TECHNOLOGY DEVELOPMENT MISSIONS

- A TECHNOLOGY DEVELOPMENT (TD) MISSION IS AN EXPERIMENTAL PROJECT THAT IS AIMED AT ADVANCING SPACE TECHNOLOGY AND RECEIVES SUPPORT FROM THE SPACE STATION. THE SCOPE OF TD MISSIONS IS VERY BROAD, WITH VALUE FOR SCIENCE, APPLICATIONS, COMMERCIAL USES, NATIONAL DEFENSE, AND ENHANCEMENT OF NASA'S CAPABILITIES AND ROLE IN SPACE.

- TD MISSIONS AS DEFINED HERE ARE NOT PROJECTS TO DEVELOP ENABLING TECHNOLOGY FOR THE FIRST SPACE STATION. HOWEVER, WITH SUPPORT FROM THE FIRST OR SUBSEQUENT STATIONS THEY COULD DEVELOP TECHNOLOGY FOR MODIFIED OR LATER GENERATION STATIONS.

- TD MISSION REQUIREMENTS INFLUENCE THE DESIGN OF THE SPACE STATION THAT WILL SUPPORT THEM. THEY WILL INFLUENCE THE DESIGN OF THE FIRST SPACE STATION.

- THE POTENTIAL ROLE OF A SPACE STATION IN TD MISSION SUPPORT IS OUTLINED AND EXAMPLES OF TD MISSIONS ARE PRESENTED. A FORMAT FOR DESCRIBING CANDIDATE TD MISSIONS IS INDICATED.

POTENTIAL SPACE STATION SUPPORT OF
TECHNOLOGY DEVELOPMENT MISSIONS

RELATIONSHIP TO PAYLOAD

- SUPPORT FOR INTERIOR-MOUNTED PAYLOADS
- BASE FOR ATTACHING EXTERNAL PAYLOADS
- BASE FOR ORBITAL ASSEMBLY/CHECKOUT
- BASE FOR PERIODIC VISITS FOR MAINTENANCE/RESUPPLY
- CONTROL CENTER FOR NEAR-VICINITY FREE FLYERS

POTENTIAL SPACE STATION SUPPORT OF TECHNOLOGY DEVELOPMENT MISSIONS

AVAILABLE OPERATIONAL CAPABILITIES/CONDITIONS

- o HUMAN INTERFACE/EXPERIMENT ACCESSIBILITY
- o ABILITY TO HANDLE LARGE SIZE (WITH EVA AND MMU)
- o LONG TERM OPERATIONS CAPABILITIES
  - ITERATIVE ADJUSTMENT/TESTING
  - EVOLUTIONARY DEVELOPMENT (E.G., OPTIMAL ECLSS)
  - LONG DURATION EXPOSURE, REMOVAL, REPLACEMENT
  - OTHER
- o SPACE ENVIRONMENT (LOW G, LOW P, PLASMA, RADIATION)

TECHNOLOGY MISSIONS FEASIBLE IN ALTERNATE WAYS

- CANDIDATE SPACE STATION TECHNOLOGY MISSIONS MAY BE FEASIBLE USING SPACE SHUTTLE, LDEF, FREE FLYER, OR OTHER ALTERNATIVES

- IN SUCH CASES, COMPARISON STUDIES ARE REQUIRED, BASED ON COST, SCHEDULE, ENVIRONMENTAL IMPACT OR OTHER MAJOR CRITERIA, TO DETERMINE APPROPRIATENESS AS A SPACE STATION MISSION

SOURCES OF TECHNOLOGY DEVELOPMENT MISSIONS

TECHNOLOGY DEVELOPMENT OR SCIENCE MISSIONS IN ANY OF THE CATEGORIES LISTED IN THE FIRST COLUMN BELOW MAY BE REQUIRED IN THE OAST OR SPACE STATION DISCIPLINES AND WORKING AREAS LISTED IN THE SECOND AND THIRD COLUMNS.

TECHNOLOGY CATEGORIES

- GENERIC
- FLIGHT MISSION-SUPPORTING
- OPERATIONS

SCIENCE

- PHYSICS, CHEMISTRY, OTHER EXPERIMENTS, IN SPACE ENVIRONMENT

NASA/OAST DISCIPLINE AREAS	SPACE STATION WORKING AREAS
o MATERIALS & STRUCTURES	o STRUCTURES & MECHANISMS
o ENERGY CONVERSION	o POWER, THERMAL
o COMPUTER SCIENCE & ELECTRONICS	o DATA MANAGEMENT, COMMUNICATIONS
o PROPULSION	o AUXILIARY PROPULSION
o CONTROLS & HUMAN FACTORS	o ATTITUDE CONTROL & STABILIZATION, HUMAN CAPABILITIES
o SPACE STATION SYSTEMS	o SYSTEMS/OPERATIONS TECHNOLOGY, ENVIRONMENTAL CONTROL AND LIFE SUPPORT
o FLUID & THERMAL PHYSICS, PACE (PHYSICS & CHEMISTRY EXPERIMENTS)	

ILLUSTRATIVE TECHNOLOGY DEVELOPMENT MISSIONS

MAJOR INITIAL TD MISSION

- MEASURE SPACE STATION PERFORMANCE/BEHAVIOR
  - INSTALL EXTENSIVE INSTRUMENTATION, SENSORS ON SPACE STATION STRUCTURES, SUBSYSTEMS
- COMPARE WITH PREDICTIONS BASED ON
  - GROUND EXPERIMENTS
  - ANALYTICAL MODELS/SIMULATION
- EVALUATE RESULTS FOR INFORMATION ON
  - BEHAVIOR OF OPERATIONAL LARGE SPACE SYSTEMS
  - ABILITY TO PREDICT WITH EXISTING TOOLS/TECHNIQUES
  - TECHNOLOGY NEEDS
- DEFINE REQUIRED ADDITIONAL TECHNOLOGY DEVELOPMENT MISSIONS

GENERIC TECHNOLOGY DEVELOPMENT MISSIONS

EXAMPLES

- LARGE SPACE STRUCTURES:

  FOR CANDIDATE FLEXIBLE SPACE STRUCTURES,

  - COMPARE MEASURED AND PREDICTED VIBRATIONAL MODES, FREQUENCIES
  - INVESTIGATE METHODS TO CONTROL ATTITUDE, SHAPE, VIBRATIONS

- FLUID SYSTEMS:

  INVESTIGATE TWO-PHASE STATIONARY AND FLOW PROCESSES IN LOW G

  - BUBBLE FORMATION, BEHAVIOR
  - THERMAL STRATIFICATION
  - WICKING PERFORMANCE

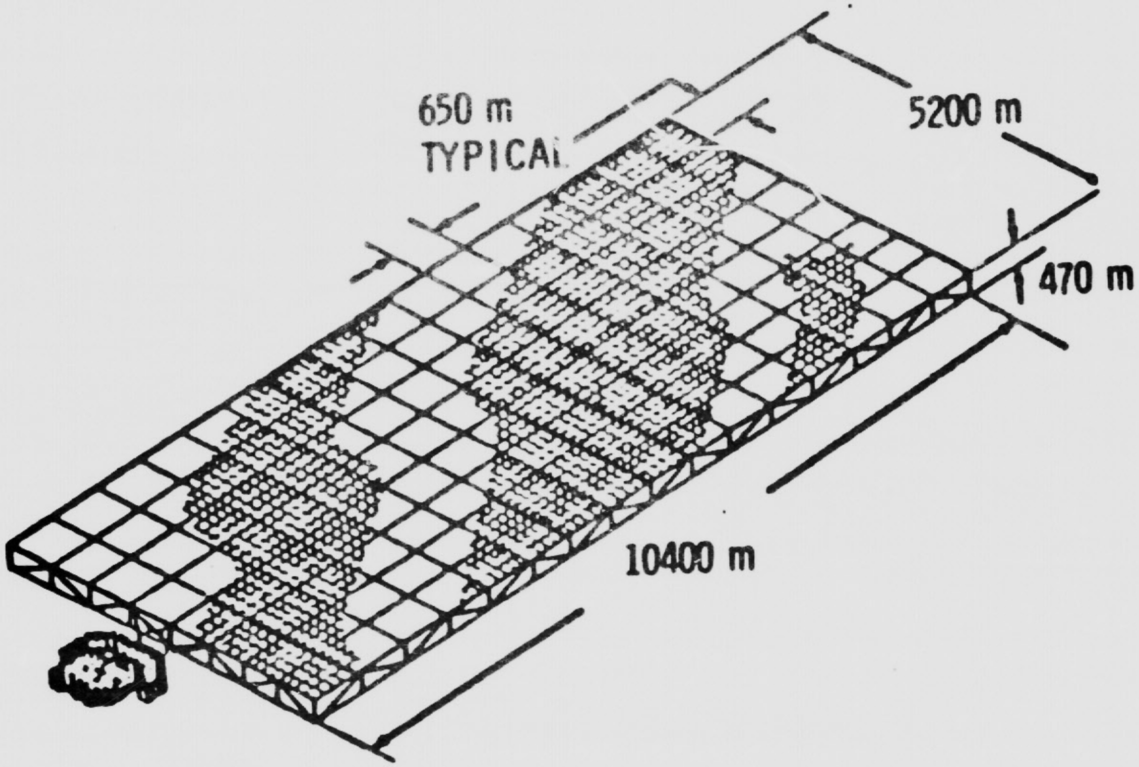
- MATERIALS:

  INVESTIGATE CHANGES IN PROPERTIES WITH EXPOSURE DURATION

  - PERIODIC INSPECTION, REMOVAL, ANALYSIS, REPLACEMENT

- OTHER

CONFIGURATION



- REQUIREMENTS
  - ORBIT
  - SOLAR COLLECTOR ATTITUDE CONTROL
  - MPTS POINTING
  - STATIONKEEPING

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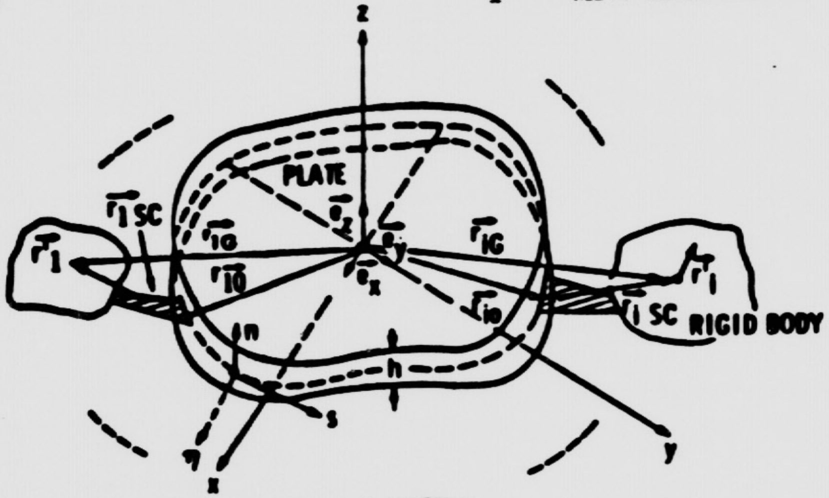
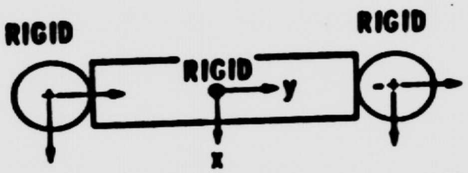
MODELING

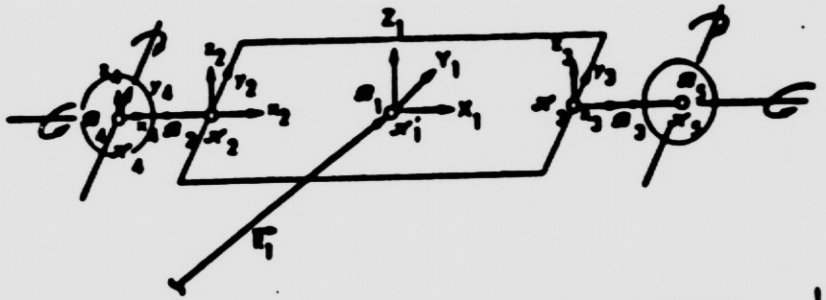
- COMBINED COLLECTOR/MPTS DYNAMICS



- CONTINUUM MODEL
- 1 FLEXIBLE BODY WITH ATTACHMENTS
- PARAMETRIC ANALYSIS

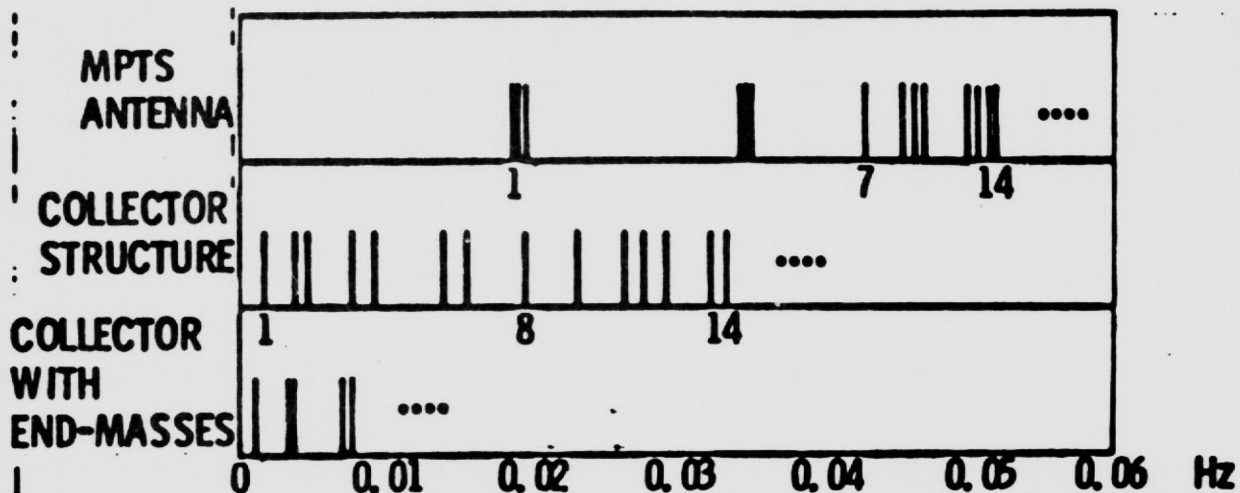


- MULTIBODY MODEL
- 3 HINGE-CONNECTED BODIES
- INITIAL CONCEPT DEVELOPMENT



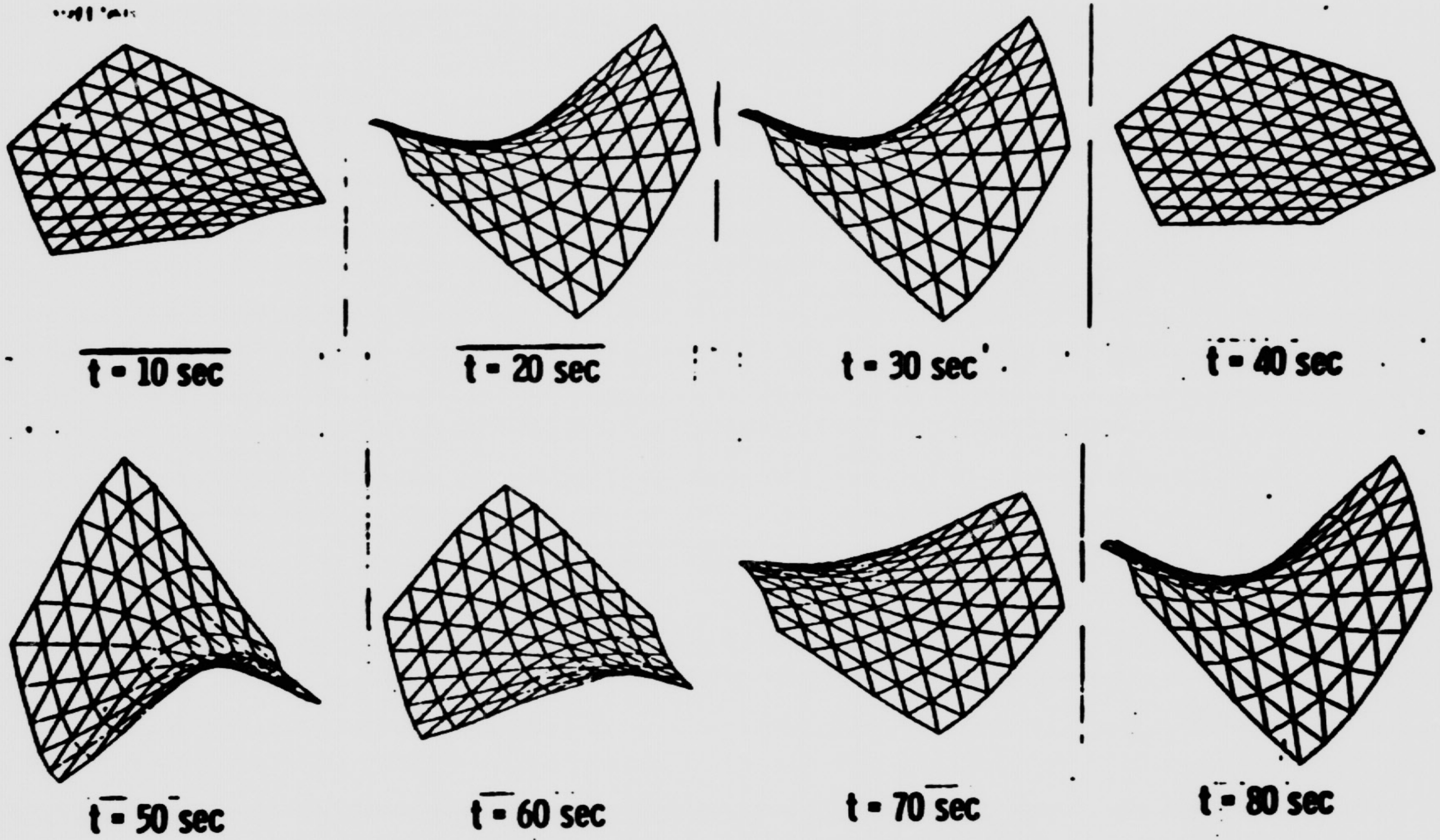
- FLEXIBLE MULTIBODY MODEL
- 5 HINGE-CONNECTED BODIES
- COMPLETE DYNAMIC/CONTROL VERIFICATION

MODAL FREQUENCIES OF SPS



- THE SPS AND THE ANTENNA'S FUNDAMENTAL FREQ'S ARE 2 TO 3 ORDERS OF MAGNITUDE GREATER THAN THE ORBITAL FREQ
- THE 1ST MODE OF ANTENNA IS 1 ORDER OF MAGNITUDE GREATER THAT OF THE PLATE
- THE FIRST 3 MODES OF THE ANTENNA OVERLAPS WITH THE 8TH MODE OF THE PLATE
- THE ANTENNA MASSES DO NOT REDUCE THE SPS FREQ'S SIGNIFICANTLY NOR DOES THE COUPLING STIFFNESS
- THE MOST SIGNIFICANT FACTORS ARE THE ASPECT RATIO, AND DEPTH OF PLATFORM

MODAL TRANSIENT RESPONSE
(FIRST FLEXIBLE MODE)



EXAMPLES OF RELEVANCY

- LARGE STRUCTURES/STABILITY & CONTROL

  - NATIONAL SECURITY: LARGE ($\sim$ 100M) DEPLOYABLE ANTENNAS ARE SOUGHT BY THE MID - 90'S*

  - RADIO ASTRONOMY: DESIRE PARABOLIC DISH ANTENNAS UP TO 100 FT IN DIAMETER, ANTENNA ARRAYS 1- TO 20-KILOMETER IN EXTENT

  - SOLAR CELL ARRAYS IN NEAR-EARTH ORBIT (30° i): 50KW AVERAGE POWER REQUIRES AN ACTIVE AREA > 7,500 FT^2

* COLONEL NORMAN W. LEE, JR., DEPUTY FOR TECHNOLOGY, USAF SPACE DIVISION, "NATIONAL SPACE OUTLOOK, USAF SPACE TECHNOLOGY NEEDS", PRESENTED TO THE NATIONAL SPACE CLUB CONFERENCE, 22-23 JUNE 1982, PAGE B-1697, T-33.

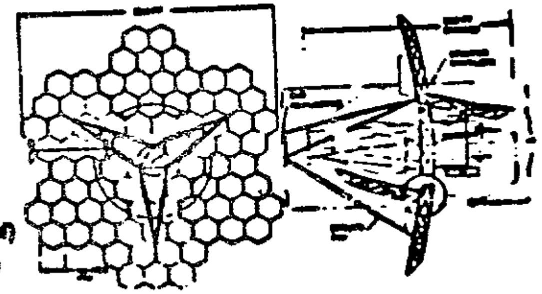
FLIGHT MISSION-SUPPORTING TECHNOLOGY DEVELOPMENT MISSIONS

- TECHNIQUE DEVELOPMENT, PERFORMANCE VERIFICATION, OTHER, IN SPACE ENVIRONMENT; FOR SPECIFIC MISSIONS

- MISSION CATEGORIES

  - SCIENCE
  - APPLICATIONS
  - COMMERCIAL
  - NATIONAL SECURITY

LARGE OPTICAL-CLASS REFLECTOR PAYLOADS



Operations Challenges

- Deployment, Assembly, or Hybrid Setup
- Support Structure Rigidization
- Thermal Stabilization/Compensation
- Figure Control Activation and Checkout
- Shape Measurement and Alignment (Partial/Total)
- Spacecraft Integration (Upper Stage If Required)
- Spacecraft Checkout and Launch
- Time Required: Probably Weeks Vs Days (Platform Vs Shuttle)

Structure Challenges

- Support Structures Must be Compactable Yet Rigidizable
- Compactable Structures Have Many Articulation Joints, Which are by Nature:
  - Free To Move in At Least One Axis
  - Difficult To Analyze/Predict As To Dynam[illegible]
  - Difficult To Solidify Rigidize
- Rigid Structures Require High-Load, Rigid Joints
- Bolted Joints (EVA) Probably Have Benefits Over Automatically Actuated Joints (Load Capability, Dyn[illegible]ics, Cost and Reli[illegible])

OPERATIONS TECHNOLOGY DEVELOPMENT MISSIONS

EXAMPLES

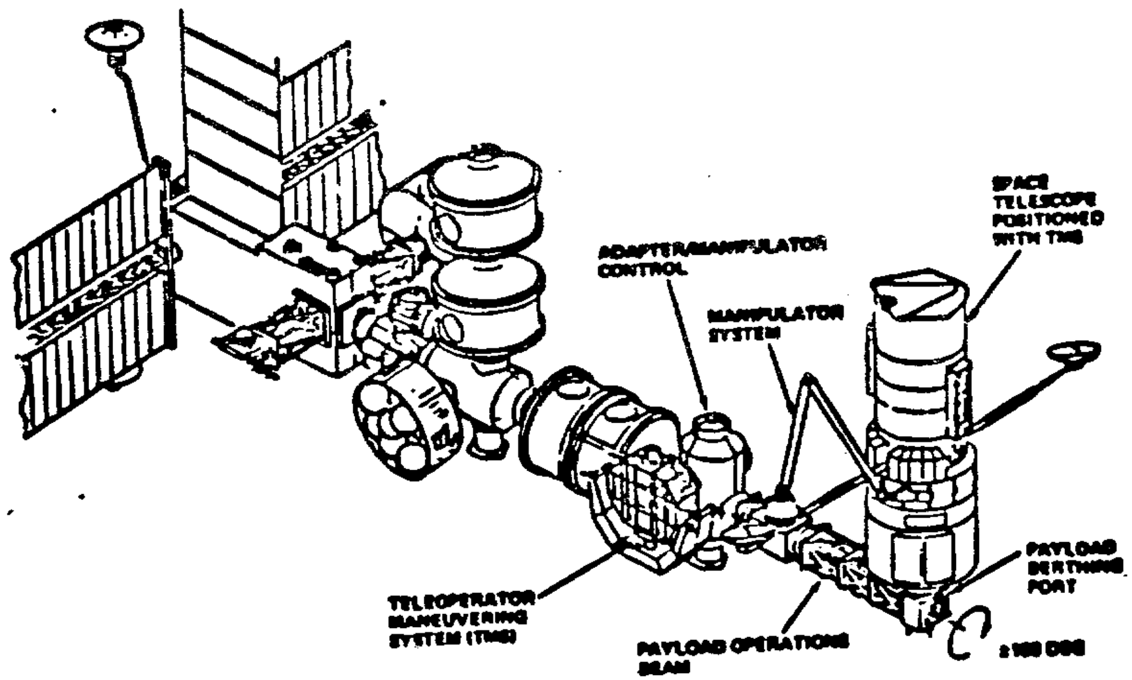
ON-BOARD

- LIFE SUPPORT TECHNOLOGY ADVANCEMENT
- CONTAMINATION CONTROL
- SPACECRAFT CHARGING CONTROL
- HIGH VOLTAGE/PLASMA INTERACTION REDUCTION
- FIRE SAFETY TECHNOLOGY
- OTHER

OFF-BOARD

- CONSTRUCTION OPERATIONS ADVANCEMENT
- SATELLITE SERVICING ENABLEMENT
- OTV FLIGHT SUPPORT ENABLEMENT
- OTHER

SERVICING RETRIEVABLE SPACECRAFT



CRYOGENIC OTV EXPERIMENTS

Propellant Fill and Drain

- Transfer Line Chilldown
- Tank Prechill (In-Orbit Chilldown vs Ground Chilldown)
- Tank Fill Without Venting
- Loading Accuracy
- Loading Times With Partial Acquisition Device on Tanker

Propellant Storage (Long-Term)

- Insulation — MLI vs MLI/VCS
- Zero-G Vent System

Tank Assembly

- Latching
- Umbilical Sealing

Monitoring and Maintenance

PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE

EXAMPLES

- TRICRITICAL POINT STUDY IN CRYOGENIC MIXTURES
- CONVECTION IN SOLIDIFYING BINARY MIXTURES
- FLOAT ZONE EXPERIMENTAL STUDY
- FLAME SPREADING IN REDUCED GRAVITY
- BOUYANCY EFFECTS ON VAPOR FLAME AND EXPLOSION PROCESSES
- IMMISCIBLE LIQUID DROPLET MOTION
- ELECTROHYDRODYNAMICS OF DROPS, BUBBLES & FLUID CYLINDERS
- CRYOGENIC EQUIVALENCE PRINCIPLE EXPERIMENT

FORMAL DESCRIPTION OF TECHNOLOGY DEVELOPMENT MISSIONS

RECOMMENDED FORMAT

I. MISSION TITLE

II. MISSION DESCRIPTION

III. BENEFIT

IV. JUSTIFICATION

V. MISSION REQUIREMENTS & CAPABILITIES

VI. SPACE STATION VS. FREE FLYER

FORMAL DESCRIPTION OF TECHNOLOGY DEVELOPMENT MISSIONS

EXAMPLE:

FLUID MANAGEMENT TECHNOLOGY

I. Mission Objectives

To provide a technology base for systems requiring storage, acquisition and transfer of both earth storables and cryogens under controlled reduced gravitational conditions.

II. Mission Description

The missions proposed will provide the technology for the long term storage, acquisition and transfer of both single and two-phase fluids. Key issues regarding fluid mechanics, heat transfer and thermodynamics of these complex physical systems need to be addressed. Specific experiments must be conducted on surface tension screen acquisition devices, pool boiling, two-phase flow boiling, fluid reorientation and transfer utilizing noncryogenic fluids.

Because of the unlimited number of experiments which could potentially be conducted in this category, this mission could substantially benefit from a manned technology development laboratory. It is envisioned that this laboratory could be connected to the space station through some isolation structure or be flown in a manned free flyer to minimize extraneous disturbances.

III. Benefit

Life support systems and environmental control systems can be more efficiently designed with an improved knowledge of two-phase heat and mass transfer under low-g. Long duration fluid management experiments would provide designers of Orbital Transfer Vehicles enabling technology.

IV. Justification

Advanced Fluid Management Technology Missions will require a long duration, controlled low gravity environment. In addition to very low levels, selected discrete gravity levels at some TBD level will also be required. An auxilliary propulsion system will be required to control these low gravity levels.

V. Mission Requirements & Capabilities

A) Orbital Parameters - None

B) Mass, volume, operational envelope mass is TBD but an estimated volume of four times the Spacelab volume on Space Shuttle may be required for a technology development laboratory. A key element to any manned operating laboratory is space.

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C) Power - The power requirements are experiment peculiar. However it is anticipated that both AC and DC power at normal levels available in earth-bound laboratories will be required.

D) Thermal Control - Thermal control for the individual experiments will be experiment peculiar and should not be a requirement of the space station. Thermal control of the laboratory, however, should be available and operational to earth based laboratory values. This issue may be related to environmental control.

E) Attitude, Stabilization - The Laboratory Concept must operate in a gravitational environment which must be capable of providing controlled low acceleration levels. An auxilliary propulsion system will be required to provide this control and is considered a separate technology mission.

F) Viewing - No requirements

G) Environmental Constraints - TBD

H, I) Data Management, Communications, Crew Timeline - The Space Station Technology Development Laboratory will need to be manned to perform technology experiments in real-time. Payload specialists will need to be trained to operate and upkeep Data Management System, conduct tests and transmit data back to earth for subsequent analysis. Crew timelines should be scheduled to eliminate undesireable g-jitter disturbances to experiments.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station VS. Free Flyer

The technology experiments identified have both safety and acceleration control requirements that may require trade studies between Space Station and Free Flyer. In either case, this laboratory should be capable of providing controlled low levels of Reduced Gravity. The laboratory concept is envisioned to provide adequate space, power, thermal control and basic experimental services such as supply air, etc. Experiment peculiar instrumentation would not be a part of this laboratory.

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CANDIDATE TECHNOLOGY DEVELOPMENT MISSIONS DESCRIBED IN ATTACHMENT A

Crew Systems:
- Emesis Station
- Dishwasher/Clothes Washer Appliances

Long Term Cryogenic Fluid Storage Technology
Fluid Management Technology
Fire Safety Technology
Controlled Acceleration Propulsion Technology
Large Space Power System Technology Demonstration
Ion Thruster Effects on LEO Power Systems
Liquid Droplet Radiator

Large Structure Technology Experiments
Attitude Control
- System Identification Experiment
- Adaptive Control Experiment
- Distributed Control Experiment

Zero "G" Antenna Range Communications Experiment
Laser Communication and Tracking Development Experiment
Teleoperator Real Time Communications Experiment
Multi-Frequency High Gain Antenna Control Experiment

Space Structures Technology Development/Dynamics of Lightly Loaded Structures
Spacecraft Strain and Acoustic Emission Sensors
Spacecraft Materials Technology
Spacecraft Control Technology Development
- Advanced Adaptive Control Technology Demonstration
- Advanced Control Device Technology Demonstration
- Thermal Shape Control Technology

Large Antenna Development/LSA Short and Long Baseline Technology Development and Utilization
Earth Observations Instrument Development:
- MAPS (Measurement of Air Pollution from Satellite)
- CO2 Lidar for Atmospheric Trace Gas Concentration and Wind Velocity/Transport Measurements
- Satellite Doppler Meteorological Radar Technology Development
- Microwave Remote Sensing Technology - Passive Systems
- Earthbound Oriented Instrument Development

Advanced Energetics Research:
- Deployment and Testing of Large Solar Concentrator
- Test Solar-Pumped Lasers
- Laser-to-Electric Energy Conversion
- Laser Propulsion Test
- Solar-Sustained Plasmas

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Electronics Materials Processing:
- Growth of Compound Semiconductor Crystals
- Growth of Thin Single Crystal Rhodium Wafers

Space Manufacturing and Processing Technology Development /Fabrication of Lightweight Cryogenic Heat Pipes

Space Teleoperator Systems Research/Manipulator Controls Technology

Space Station Acoustics Control Technology Development/Noise and Vibration Habitability Criteria Validation

Active Optics Technology
Cryogenic Lifetime Technology
Space Component Lifetime Technology
Materials and Coating Technology

Large Space Structure Technology
Satellite Servicing Technology
OTV Servicing Technology

Tether Dynamics Technology
Earth Observation Sensor Definition
Earth Feature Identification Analysis Techniques and Automated Systems Definition
Earth Observing Technique Development
Materials Processing Technology
- Process and Technique Analysis and System and Procedure Development

Electrophoresis Separation of Medical Materials Technology
Low Cost Modular Solar Panel Technology
Geodesic Spherical Structures Technology

Zero-Gravity Bromine Phase Separation Experiment

SUMMARY

- TECHNOLOGY DEVELOPMENT MISSIONS WILL CONTRIBUTE TO SPACE STATION PROGRAM DEFINITION AND DESIGN SPECIFICATIONS.

- A NUMBER OF CANDIDATE TECHNOLOGY DEVELOPMENT MISSIONS ARE INDICATED IN THESE NOTES. THE MISSIONS WERE DEFINED BY NASA STAFF AND THEY IDENTIFY AREAS OF TECHNOLOGY NEED AND INTEREST. HOWEVER, THEY ARE NOT, AT PRESENT, OFFICIALLY APPROVED NASA PROJECTS.

- IDENTIFICATION OF ADDITIONAL TECHNOLOGY DEVELOPMENT MISSIONS, TIME-PHASING OF ALL THE TD MISSIONS, AND APPLICATION TO SPACE STATION DESIGN AND PROGRAM DEFINITION WOULD BE DESIRABLE.

IId COMMERCIAL REQUIREMENTS

JOHN COLE, MODERATOR

SPACE STATION TASK FORCE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INDUSTRY INTERACTION

RONALD J. PHILLIPS

DIRECTOR

TECHNOLOGY UTILIZATION AND INDSUTRY AFFAIRS OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INDUSTRY FAMILIARITY WITH SPACE-RELATED VENTURES

UNKNOWNS

- CHARACTERISTICS AND "VALUE" OF SPACE ENVIRONMENT
- CAPABILITIES OF SPACE TECHNOLOGY/SYSTEMS
- POTENTIAL PRODUCTS/PROCESSES HAVING COMMERCIAL VALUE

- ENTRY COSTS ASSOCIATED WITH EXPERIMENTATION IN SPACE
- LEAD TIMES REQUIRED TO DESIGN EXPERIMENTS AND SCHEDULE STS FLIGHTS
- GOVERNMENT CONTROLS MEANS OF ACCESS TO SPACE

INDUSTRY IS GENERALLY UNABLE TO ASSESS RISK VS. RETURN

AND

LIKELIHOOD OF FINANCIAL SUCCESS

NASA/INDUSTRY JOINT VENTURE POSSIBILITIES

- o EARLY USAGE IN SPACE POLICY STATEMENT AND JOINT ENDEAVOR GUIDELINES
  - REDUCE INDUSTRY FINANCIAL EXPOSURE
  - REDUCE INDUSTRY RISK ASSOCIATED WITH;
    - -- TECHNOLOGICAL PERFORMANCE UNCERTAINTIES
    - -- R & D COST UNCERTAINTIES
    - -- MARKET UNCERTAINTIES

- o SPECIFIC POSSIBILITIES
  - TEA'S -- EXCHANGE TECHNICAL INFORMATION AND COOPERATE IN CONDUCT AND ANALYSIS OF GROUND-BASED RESEARCH
  - IGI'S -- CORPORATE SCIENTIST COLLABORATES WITH NASA P.I. ON SPACE FLIGHT EXPERIMENT
  - JEA'S -- LEGAL AGREEMENT HAVING COMMERCIAL PRODUCT/PROCESS AS END OBJECTIVE

INDUSTRY INITIATIVES
(AS OF SEPTEMBER 14)

- AGREEMENTS
  - 5 JEA'S PROPOSED OR SIGNED
  - 4 TEA'S PROPOSED OR SIGNED
  - 4 MOU'S PROPOSED OR SIGNED

- ACTIVITY
  - PROCESSING/RESEARCH ON BIOLOGICAL MATERIALS (2)
  - CRYSTAL GROWTH (1)
  - MPS RESEARCH SERVICES (2)
  - MPS RESEARCH (4)
  - HARDWARE DEVELOPMENT FOR SPACE-RELATED ACTIVITIES (3)

CAPITAL INVESTMENT IN SPACE: THE CORPORATE PERSPECTIVE

STANLEY R. GOLDBERG

CHIEF, STUDIES AND ECONOMIC ANALYSIS

TECHNOLOGY UTILIZATION AND INDUSTRY AFFAIRS OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CAPITAL INVESTMENT IN SPACE: THE CORPORATE PERSPECTIVE

I. PROJECT ATTRACTIVENESS

A. GENERAL CRITERIA:

1. SHORT PAYBACK PERIOD (TYPICALLY 3-5 YRS.)
2. SMALL RELATIVE FINANCIAL EXPOSURE
3. HIGH ROI
4. RISK NOT LARGE

OR, EQUIVALENTLY

NET POSITIVE CASH FLOW IS QUICK, SURE, LARGE

- CASH FLOW, NOT "PROFIT", IS THE IMPORTANT DETERMINANT OF THE VALUE OF A VENTURE

- REFLECTS CAUTIOUS MANAGEMENT

B. SPACE INVESTMENT CRITERIA

1. HIGH VALUE PRODUCT
2. SUBSTANTIAL ADVANTAGE TO SPACE VS. GROUND PROCESSING
3. SPACE PROCESSES CAN BE DEVELOPED IN A GIVEN, REASONABLE TIME AT AN AFFORDABLE COST
4. MARKET EXISTS AT A REASONABLE PRICE
5. MARKET WILL NOT DISAPPEAR
   a. NEW RIVAL PRODUCTS
   b. TECHNOLOGICAL BREAKTHROUGH PERMITTING COMPETITIVE GROUND PRODUCTION

- INDUSTRIAL MANAGEMENT APPARENTLY NOT WILLING TO INVEST IN SPACE UNTIL IT IS REASONABLY ASSURED OF AN ATTRACTIVE RETURN

- UNDERMINES EXPLORATION OF COMMERCIAL POSSIBILITIES

II. INVESTMENT IN SPACE

- EXPERIENCE THUS FAR INDICATES

  1. SHORTAGE OF IDEALS REGARDING POTENTIALS OF SPACE
  2. INDUSTRY'S INABILITY TO IDENTIFY NEW PRODUCTS, NEW PROCESSES, NEW MARKETS WITH EXTREMELY LUCRATIVE COMMERCIAL POTENTIAL

     - FEW NON-AEROSPACE FIRMS EVEN RELATE RESEARCH IN SPACE TO THEIR OWN OPERATIONS

- THAT IS, MANY FIRMS CURRENTLY INVOLVED IN SPACE-RELATED MAKRET ANALYSIS ARE SEEKING TO IDENTIFY AND DEVELOP PRODUCTS

  1. ACHIEVING HIGHEST DOLLAR VALUE PER UNIT WEIGHT AND,
  2. WHICH WILL CONSTITUTE REFINEMENTS OF ALREADY ESTABLISHED MARKETS

     - IRONIC THAT MOST SPACE APPLICATIONS PRESUMABLY WILL CREATE NEW MAKRETS

- A SOMEWHAT LIMITED FOCUS

III. NON-INVESTMENT IN SPACE

A. ECONOMICS:

1. PERCEIVED HIGH TECHNOLOGICAL AND MARKETING RISK
2. PERCEIVED LARGE INVESTMENT, LONG AND INDETERMINATE PAYBACK

   - AT BEST, "SECOND-TO-MARKET" STRATEGY

B. INSTITUTIONAL DETERRENTS:

1. DIFFICULTY IN SECURING EXCLUSIVITY OF TECHNICAL DATA AND PATENT RIGHTS FOR FIRMS DOING NASA-RELATED RESEARCH
   - GIVEN GUARANTEE OF CONFIDENTIALITY, STILL EXISTS CONCERN OVER INADVERTENT COMPROMISE OF DATA RIGHTS BY GOVERNMENT
2. LEGAL AND REGULATORY OBSTACLES
   - RIGHT TO OWN ORBITAL SLOTS OR OTHER EXTRA-TERRESTRIAL RESOURCES
   - POSSIBLE ANTI-TRUST CONFLICTS FROM THE POOLING OF RESOURCES TO OVERCOME HIGH COST/HIGH RISK NATURE OF SPACE VENTURES
   - GRANTS OF EXCLUSIVITY STILL HAVE NOT BEEN TESTED IN THE COURTS
3. DOD PRIORITIES PREEMPT TIMELY FOLLOW-UP OF COMMERCIAL ACTIVITIES
4. GOVERNMENT ACCOUNTABILITY AND LIABILITY QUESTIONED
5. PERCEIVED GOVERNMENT REGULATION, INTERFERENCE IN OPERATIONS, AND UNRESPONSIVENESS
6. POTENTIAL FOR LONG DELAYS BETWEEN FOLLOW-UP FLIGHTS DUE TO PERCEIVED OPERATIONAL INEFFICIENCIES
7. LACK OF COMMUNICATION BETWEEN GOVERNMENT AND INDUSTRY, ESPECIALLY FIRMS UNFAMILIAR WITH DOING BUSINESS WITH GOVERNMENT

C. TECHNICAL OBSTACLES:

- ABSENCE OF SUPPORTING TECHNOLOGIES
  1. ORBITAL TRANSFER VEHICLES
  2. FACILITIES FOR EXTENDED RESEARCH AND MANUFACTURING
  3. FREE FLYERS, PLATFORMS, OPERATIONAL CENTERS TO SERVICE AND HOUSE INDUSTRIAL PRODUCTION
  4. NEED BETTER UTILIZATION OF SOLAR ENERGY

PERSPECTIVES ON MATERIALS PROCESSING IN SPACE

COMMERCIAL PAYLOADS FOR SPACE STATION

CHARLES F. YOST

MATERIALS PROCESSING OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MATERIALS PROCESSING IN SPACE GOALS AND STRATEGY

- MPS HAS TWO GOALS:
  - DEVELOP AND EXPAND FUNDAMENTAL SCIENCE OF MATERIALS PROCESSING IN SPACE ENVIRONMENT
  - IDENTIFY EMERGING SPACE PROCESSING TECHNOLOGIES THAT CAN RESULT IN COMMERCIAL APPLICATION

- STRATEGY:
  - FOSTER SCIENTIFIC RESEARCH TO BUILD A BROAD KNOWLEDGE BASE OF MATERIALS PROCESSING IN A SPACE ENVIRONMENT
  - CREATE AWARENESS OF POSSIBLE COMMERCIAL OPPORTUNITIES TO INDUSTRY THROUGH PUBLICATIONS, SEMINARS, VISITS TO NASA CENTERS
  - ENCOURAGE PRIVATE SECTOR PARTICIPATION IN SPACE PROCESSING THROUGH UTILIZATION OF JOINT ENDEAVOR AGREEMENTS, TECHNICAL EXCHANGE AGREEMENTS AND INDUSTRIAL GUEST INVESTIGATOR AGREEMENTS

MPS PROCESSES

	FURNACE PROCESSING	CONTAINERLESS PROCESSING	FLUIDS/CHEMICAL PROCESSING	BIOLOGICAL PROCESSING
RESEARCH PROCESSES	• ISOTHERMAL GRADIENT FREEZE • FLOAT ZONE • DIRECTIONAL SOLIDIFICATION • VAPOR CRYSTAL GROWTH • ELECTROEPITAXY ETC.	• ACOUSTIC • ELECTROMAGNETIC • ELECTROSTATIC		• ELECTROPHORESIS • ISOELECTRIC FOCUSING • ISOTACHOPHORESIS • ETC
TYPICAL EXPERIMENTS	• CRYSTAL GROWTH FROM MELT • CRYSTAL GROWTH FROM SOLUTION • CRYSTAL GROWTH FROM VAPOR • SEMICONDUCTOR CRYSTALS • IMMISCIBLE ALLOYS • IR DETECTORS • EUTECTICS-MONOTECTICS • COMPOSITE MATERIALS	• ULTRA HIGH TEMP. MATERIALS • GLASS PROCESSING • IMMISCIBLE GLASSES • FUSION TARGETS	• LARGE SCALE CHEMICAL PROCESSING - POLYMERIC PROCESSING • LOW TEMPERATURE CRYSTAL GROWTH • MEASUREMENT OF THERMODYNAMIC PHENOMENA • HIGH VOLUME BIOLOGICAL PURIFICATION & SEPARATION • MEASUREMENT OF TRANSPORT PHENOMENA • CHEM. DEPOSITION • CATALYSIS • FLUID DYNAMIC STUDIES	• SEPARATION OF PHARMACEUTICAL MATERIALS • BLOOD PROPERTIES

ENGINEERING REQUIREMENTS FOR MPS PAYLOADS CENTER
ON FOLLOWING QUESTIONS:

POWER

ENERGY

HEAT REJECTION/COOLING

REVISIT/RESUPPLY

DATA ACQUISITION/PROCESSING

ROLE OF MAN VS AUTOMATION -- TRADEOFFS

WEIGHT

SIZE

GRAVITY REQUIREMENTS/G-JIGGLE TOLERANCE

ACCELEROMETER INFORMATION REQUIRED

TEMPERATURE CONTROL

DEVIATION

TELEMETERING/GROUND COMMAND

Established Ranges of MPS Payload Processing Parameter Values

PAYLOAD CAPACITY	PROCESSING TEMPERATURE (°C)		PROCESS TIME PER SAMPLE HOURS (DAYS)		SAMPLE DIAMETER (CM)		SAMPLE LENGTH (CM)		NUMBER OF SAMPLES PER INVESTIGATION	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
• ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (ISOTHERMAL)	200	2500	0.5	20	0.25	5	1	30	3	50
• ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (DIRECTIONAL SOLIDIFICATION)	500	2600	2.8	2160 (90)	0.5	15	2.5	120	3	≥ 100
• HIGH GRADIENT DIRECTIONAL SOLIDIFICATION	500	2600	190 (< 8)	2160 (90)	0.5	15	2.5	120	3	≥ 100
• FLOAT ZONE	500	2000	1.4	2160 (90)	1	13	15	150	3	≥ 100
• ACOUSTIC CONTAINERLESS	600	3000	0.017	2	0.2	15	-	-	3	≥ 100
• ELECTROMAGNETIC CONTAINERLESS	100	5000	0.017	0.33	5×10^{-3}	2.5	-	-	3	100
• ELECTROSTATIC CONTAINERLESS	600	3000	0.017	2	0.2	15	-	-	3	≥ 100
• SOLUTION CRYSTAL GROWTH	20	150	20	2160 (90)	0.5 LITER	5 LITER	-	-	3	20
• VAPOR CRYSTAL GROWTH	20	1600	100 (< 5)	150 (< 7)	1	4	10	30	10	40
• BIOPROCESSING	0	37	25	> 250 (< 11)	$100 cm^3$	~4000 cm^3	-	-	3	20

Established Ranges of MPS Payload Processing Parameter Values (Continued)

PAYLOAD CAPACITY	ESTIMATED PAYLOAD WEIGHT (KG)		ESTIMATED PAYLOAD VOLUME (M^3)		REQUIRED PAYLOAD POWER (KW)		REQUIRED PAYLOAD ENERGY (KW-HR)	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
● ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (ISOTHERMAL)	750	1750	2.75	6.4	1.5	22.0	0.75	47520
● ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (DIRECTIONAL SOLIDIFICATION)								
● HIGH GRADIENT DIRECTIONAL SOLIDIFICATION	800	2300	3.2	7.2	2.5	40.0	480	54000
● FLOAT ZONE	400	750	1.8	3.5	4.0	40.0	5.6	54000
● ACOUSTIC CONTAINERLESS	700	1600	2.5	5.7	1.5	26.0	0.03	52
● ELECTROMAGNETIC CONTAINERLESS	600	2500	2.1	8.9	2.0	12.0	0.04	26000
● ELECTROSTATIC CONTAINERLESS	700	1600	2.5	5.7	1.5	26.0	0.03	52
● SOLUTION CRYSTAL GROWTH	300	650	1.0	2.2	1.0	14.0	20	31000
● VAPOR CRYSTAL GROWTH	300	650	1.0	2.5	2.5	30.0	250	4500
● BIOPROCESSING	100	500	0.3	1.6	2.5	11.0	62.5	24000

RATIONALE

		APPROACH	NUMBER OF PROCESSING CHAMBERS	SAMPLE SIZE DIAMETER (CM)/LENGTH	PROCESSING TIME PER SAMPLE (HOURS)	GROWTH/CONTINGENCY (%)	POWER (KW)	ENERGY (KW-HR)	SAMPLE HANDLING AND STORAGE (NO. OF SAMPLES)	INSTRUMENTATION AND ACCESS
WEIGHT/VOLUME	MINIMUM 750 Kg $2.75M^3$	• BOTTOM OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	15/120	190	NONE	18	5.0×10^7	SINGLE SAMPLE	MINIMUM
	SELECTED 1320 Kg $4.8M^3$	• MULTIPLE CHAMBERS/SAMPLES • ISOTHERMAL/DIRECTIONAL SOLIDIFICATION CAPABILITY • FLEXIBILITY/GROWTH	2	5/30	10* 20**	25/10	12	2.6×10^4	300	FULL
	MAXIMUM 1750 Kg $6.4M^3$	• TOP OF ENVELOPE • USE 25 KW • MULTIPLE CHAMBERS/SAMPLES • FLEXIBILITY/GROWTH	4	5/30	10* 20**	25/10	24	5.2×10^4	500	FULL
ENERGY/POWER	MINIMUM 1.5Kw 0.75 KWHR	• BOTTOM OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	0.25/1	0.5	NONE	1.5	0.75	SINGLE SAMPLE	MINIMUM
	SELECTED 25 KW 5.4×10^4KWHR	• MULTIPLE CHAMBERS/SAMPLES • ISOTHERMAL/DIRECTIONAL SOLIDIFICATION CAPABILITY • FLEXIBILITY/GROWTH	2	10/30	10* 20**	25	25	5.4×10^4	300	FULL
	MAXIMUM 22 KW 6.2×10^7KWHR	• TOP OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	15/120	TOTAL MISSION	25	22	6.2×10^7	SINGLE SAMPLE	FULL

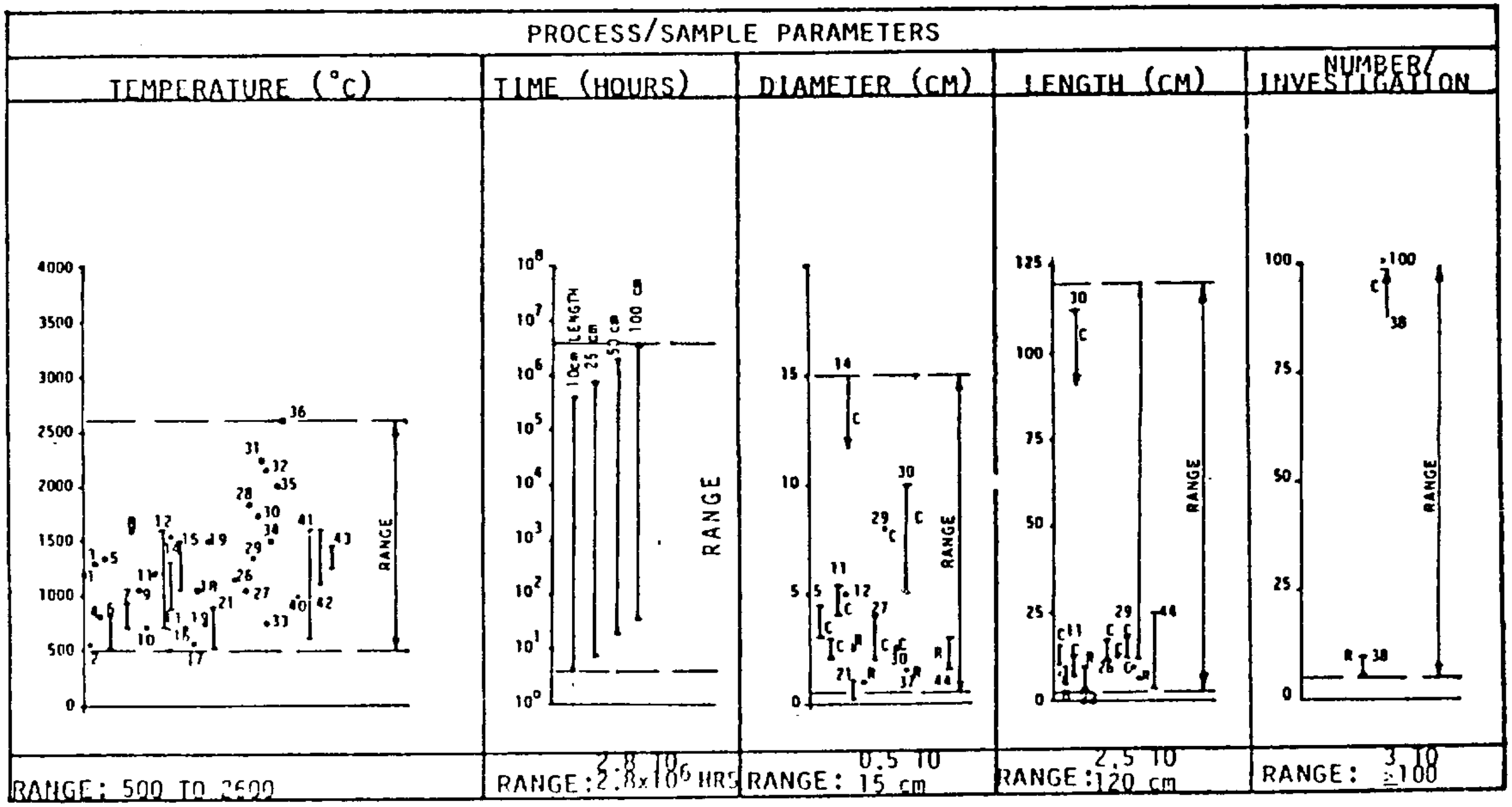
*ISOTHERMAL ** DIRECTIONAL SOLIDIFICATION

Advanced Solidification Experiment System

ISOTHERMAL		DIRECTIONAL SOLIDIFICATION	
ISSUED	REQUIREMENTS	ISSUES	REQUIREMENTS
• HEAT-UP	• ISOTHERMAL UP TO 200°C TO 2500°C	• HEAT-UP	• ISOTHERMAL UP TO 500°C TO 2600°C
• SOAK	• ISOTHERMAL AT 200°C TO 2500°C	• SOAK	• ISOTHERMAL AT 500°C TO 2600°C
• COOL DOWN	• $\leq$ 1000°C/MIN	• COOL DOWN	• $\leq$ 1000°C/MIN
• TEMPERATURE UNIFORMITY	• ISOTHERMAL $\pm$ 0.05% OF TEMPERATURE LEVEL, DURING QUENCH AXIAL TEMPERATURE UNIFORMITY $\pm$ 0.25°C/CM	• TEMPERATURE UNIFORMITY	• ISOTHERMAL $\pm$ 0.05% OF TEMPERATURE LEVEL
• THERMAL GRADIENT	• NONE	• THERMAL GRADIENT	• 150°C/CM TO 500°C/CM
• "g" LEVEL	• $\leq 10^{-5}$	• "g" LEVEL	• $\leq 10^{-5}$
• ENVIRONMENT	• VACUUM OR GAS	• ENVIRONMENT	• VACUUM OR GAS
• PROCESS RATE	• 0.05 CM/HR TO 25 CM/HR	• PROCESS RATE	• SEMICONDUCTORS 0.04 TO 40 CM/HR BRIDGMAN 5 TO 20 CM/HR CZOCHRALSKI SINGLE CRYSTAL OXIDES 0.02 TO 0.[illegible] CM/HR BRIDGMAN 0.1 TO 0.[illegible] CM/HR CZOCHRALSKI
• SAMPLE SIZE	• RESEARCH: 0.5-5CM DIAMETER 1 TO 30 CM LENGTH COMMERCIAL: 0.5-5CM DIAMETER 1 TO 30 CM LENGTH	• SAMPLE SIZE	• RESEARCH: 0.5-5CM DIAMETER 1 TO 25 LENGTH COMMERCIAL: 5-15 DIAMETER 25-20 LENGTH
• SAMPLE STORAGE	• $\leq$ 50°C	• SAMPLE SIZE	• $\leq$ 50°C

Process Requirements Advanced Solidification Experiment System

SOURCE DATA



MATERIALS/SOURCES

SEMICONDUCTORS			SINGLE CRYSTAL OXIDES		COMPOSITES-ALLOYS
1. CdTe (A.D. LITTLE)	8. GaP (METALS RESEARCH)	15. Si-Ge (HUGHES RES LAB)	26. $BiGeO_{12}$ (CRYSTL TECHN)	33. ThO (CRYSTL TECHN)	40. Al-In (GELLES ASSOC)
2. CsCdCl (STANFORD)	9. Ge (A.D. LITTLE	16. AgAbS (HUGHES RES LAB)	27. $BiGeO_{24}$ (CRYSTL TECHN)	34. KTaNbO (UNION CRBD)	41. BiMn (GRUMMAN)
3. CuInSe (HUGHES RES LAB)	10 InSb (ATT-BELL LABS)	17. AgAsS (HUGHES RES LAB)	28. GdGaO (UNION CRBD)	35. YAlO (UNION CRBD)	42. Pb-Cu (GELLES ASSOC)
4. GaSb (ATT BELL LABS)	11. InP (METALS RESEARCH)	18 AgGaS (HUGHES RES LAB)	29. LiNbO (CRYSTL TECHN)	36. BeO (UNION CRBD	43. NICKEL BASED SUPERALLOYS (INCO)
5. GaAs (METALS RESEARCH)	12. HgCdTe (MIT WITT)	19. TlAsSe (HUGHES RES LAB)	30. LiTaO (CRYSTL TECHN)	37. GENERAL (CRYSTL TECHN)	44. GENERAL (MPS/SL)
6. GaInSb (A.D. LITTLE)	13. HgCdTe (MPS/SL-NASA-MSFC)	20. ZnInS (HUGHES RES LAB)	31. MgAlO (CRYSTL TECHN)	38. GENERAL (UNION CRBD)	R = RESEARCH C = COMMERCIAL
7. GaInTe (A.D. LITTLE)	14 Si (CRYSTAL TECHN)	21 PbSnTe (MPS/SL NASA-MSFC)	32 AlO (UNION CRBD)		
		22. GENERAL (HUGHES RES LAB)			

Advanced Solidification Experiment System - Directional Solidification

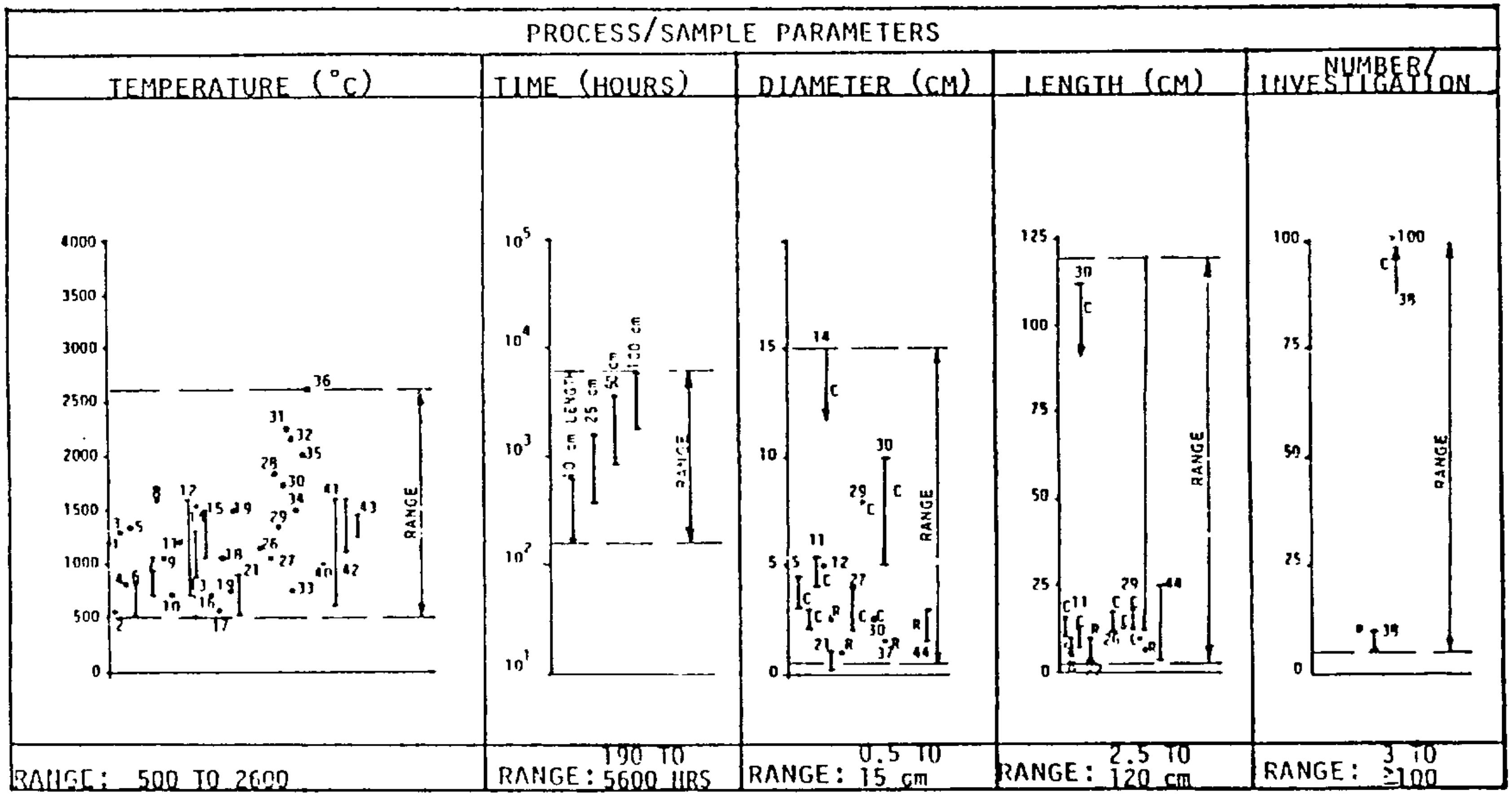
OF POOR QUALITY

RATIONALE

G/R	
RESEARCH	10^8
COMMERCIAL	10^7

		APPROACH	NUMBER OF PROCESSING CHAMBERS	SAMPLE SIZE DIAMETER/LENGTH (CM)	PROCESSING TIME PER SAMPLE (HOURS)	GROWTH/CONTINGENCY (%)	POWER (KW)	ENERGY (KW-HR)	SAMPLE HANDLING AND STORAGE (NO. OF SAMPLES)	INSTRUMENTATION AND ACCESS
WEIGHT/VOLUME	MINIMUM 800 Kg $3.2M^3$	• BOTTOM OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	15/120	TOTAL MISSION 2160	NONE	2.5	$4.8x10^2$	SINGLE SAMPLE	MINIMUM
	SELECTED 2000 Kg $6.3M^3$	• MULTIPLE CHAMBERS/SAMPLES • MINIMUM PROCESSING TIME • FLEXIBILITY/GROWTH	2	5/30	190	25/10	20	$4.3x10^4$	50	FULL
	MAXIMUM 2300 Kg $7.2M^3$	• TOP OF ENVELOPE • USE 40 KW • MINIMUM PROCESSING TIME • FLEXIBILITY/GROWTH	4	5/30	190	25/10	40	$8.6x10^4$	100	FULL
ENERGY/POWER	MINIMUM 25 KW $4.8x10^2$ KWH	• BOTTOM OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	0.5/2.5	190	NONE	2.5	$4.8x10^2$	SINGLE SAMPLE	MINIMUM
	SELECTED 25 KW $5.4x10^4$ KWHR	• MULTIPLE CHAMBERS/SAMPLES • MINIMUM PROCESSING TIME • FLEXIBILITY/GROWTH	2	5.5/30	190	25	25	$5.4x10^4$	50	FULL
	MAXIMUM 40KW $2.3x10^5$ KWHR	• TOP OF ENVELOPE • SINGLE CHAMBER/SAMPLE • NO SAMPLE HANDLING OR STORAGE	1	15/120	5600	25	40	$2.3x10^5$	SINGLE SAMPLE	FULL

High Gradient Directional Solidification System



MATERIALS/SOURCES

SEMICONDUCTORS

1. CdTe (A.D. LITTLE)
2. CsCdCl (STANFORD)
3. CuInSe (HUGHES RES LAB)
4. GaSb (ATT-BELL LABS)
5. GaAs (METALS RESEARCH)
6. GaInSb (A.D. LITTLE)
7. GaInTe (A.D. LITTLE)
8. GaP (METALS RESEARCH)
9. Ge (A.D. LITTLE
10. InSb (ATT-BELL LABS)
11. InP (METALS RESEARCH)
12. HgCdTe (MIT-WETT)
13. HgCdTe (MPS/SL-NASA-MSFC)
14. Si (CRYSTAL TECHN)
15. Si-Ge (HUGHES RES LAB)
16. AgAbS (HUGHES RES LAB)
17. AgAsS (HUGHES RES LAB)
18. AgGaS (HUGHES RES LAB)
19. TlAsSe (HUGHES RES LAB)
20. ZnInS (HUGHES RES LAB)
21. PbSnTe (MPS/SL-NASA-MSFC)
22. GENERAL (HUGHES RES LAB)

SINGLE CRYSTAL OXIDES

26. $BiGeO_{12}$ (CRYSTL TECHN)
27. $BiGeO_{24}$ (CRYSTL TECHN)
28. GdGaO (UNION CRBD)
29. LiNbO (CRYSTL TECHN)
30. LiTaO (CRYSTL TECHN)
31. MgAlO (CRYSTL TECHN)
32. AlO (UNION CRBD)
33. TeO (CRYSTL TECHN)
34. KTaNbO (UNION CRBD)
35. YAlO (UNION CRBD)
36. BeO (UNION CRBD
37. GENERAL (CRYSTL TECHN)
38. GENERAL (UNION CRBD)

COMPOSITES-ALLOYS

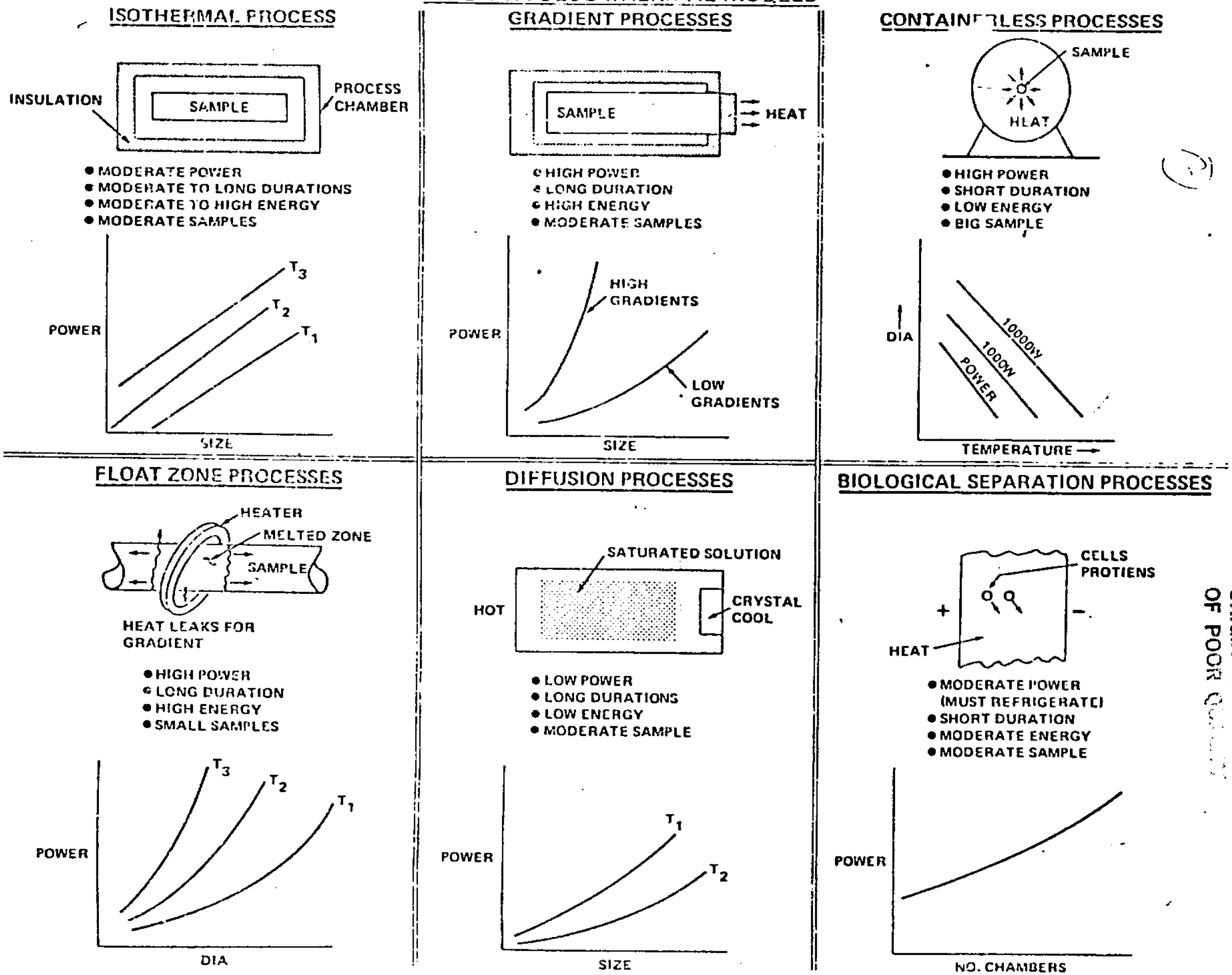
40. Al-In (GELLES ASSOC)
41. BiMn (GRUMMAN)
42. Pb-Cu (GELLES ASSOC)
43. NICKEL BASED SUPERALLOYS (INCO)
44. GENERAL (MPS/SL)

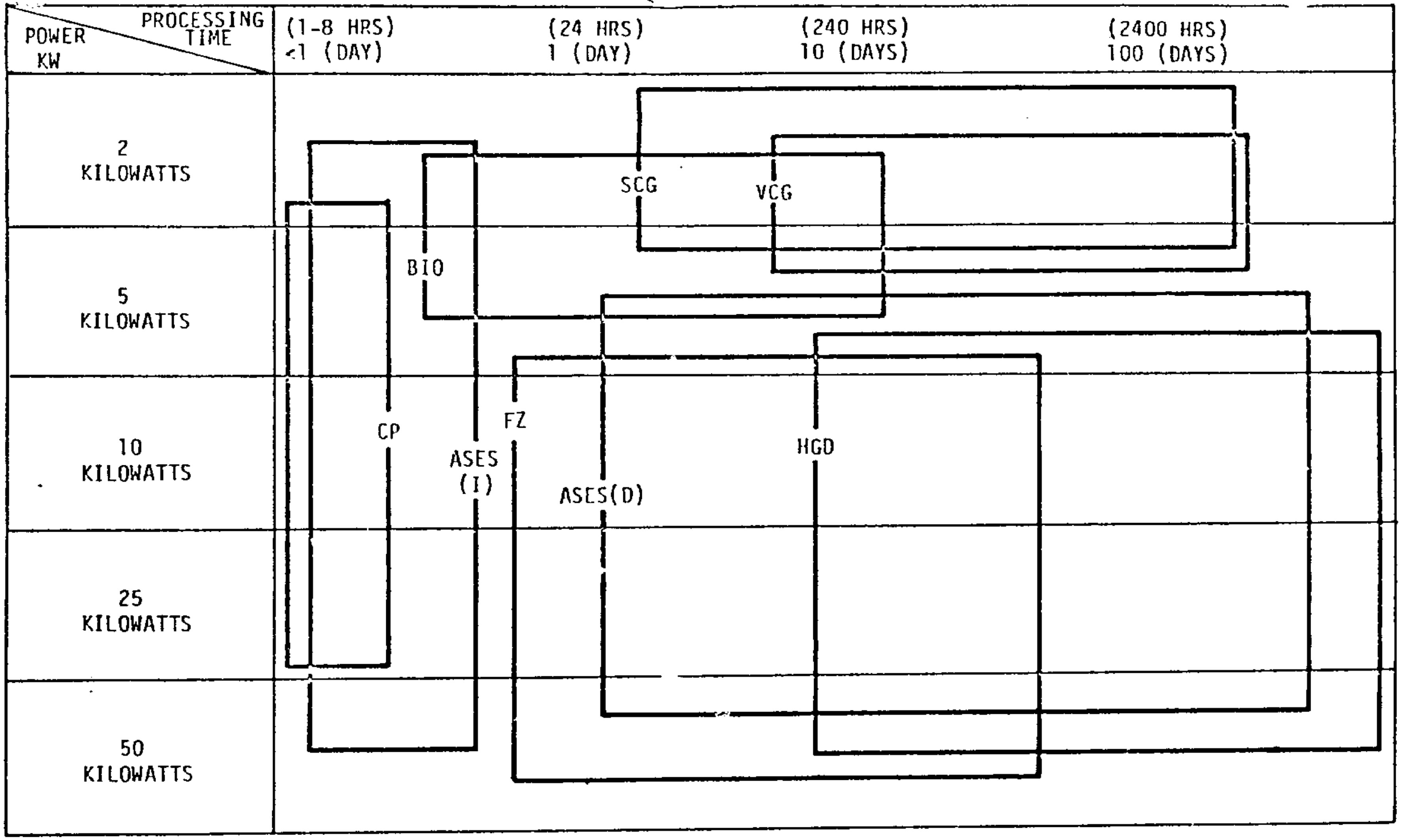
R = RESEARCH C = COMMERCIAL

High Gradient Directional Solidification System Source Data

2169-80

MPS PROCESS THERMAL MODELS





PAYLOAD SYSTEM

ASES (I)	ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (ISOTHERMAL)
ASES (D)	ADVANCED SOLIDIFICATION EXPERIMENT SYSTEM (DIRECTIONAL)
HGD	HIGH GRADIENT DIRECTIONAL SOLIDIFICATION
FZ	FLOAT ZONE
CP	CONTAINERLESS PROCESSORS (ACOUSTIC, ELECTROMAGNETIC, OR ELECTROSTATIC)
SCG	SOLUTION CRYSTAL GROWTH
VCG	VAPOR CRYSTAL GROWTH
BIO	BIOLOGICALS

Power, Time Envelopes for Single Processors, '5 Advanced Processors

2281-78

MATERIALS PROCESSING IN SPACE SYSTEM-DRIVING REQUIREMENTS DERIVED FROM BASIC PROCESSES

- ACCELERATION - 10^{-4}g - 10^{-5}g ALL PROCESSES (PARTICULARLY SOLUTION CRYSTAL GROWTH)
- MOTION - ZERO ROTATION FOR LIQUID PHASE PROCESSES
- TIME - SOLUTION CRYSTAL GROWTH (UP TO 30 DAYS)
  - CULTURE GROWTH (TYPICALLY 10-26 DAYS)
  - ZONE GROWTH (7 - 30 DAYS)
- LIFE SUPPORT - PHARMACEUTICALS 4°C - 37°C
- CONTAMINATION ENVIRONMENT - SPACE VACUUM RESEARCH FACILITY (10^6 MOLECULES/CM^2/SEC)
- VACUUM THROUGH-PUT - 10 MICRON LITERS/SEC
- POWER - CONTAINERLESS PROCESSING (TYPICALLY 10-20 KW)
- ENERGY - ZONE REFINING (TYPICALLY 100 KW HOURS PER RUN)
- WEIGHT & VOLUME - NUMBER OF SPECIMENS TO ACHIEVE COST GOAL $30-50K PER SAMPLE
- $30K-$50K EXPERIMENT FOR COMMERCIAL APPLICATION
- ORBIT ALTITUDE AND INCLINATION - ANY

SOME CONCLUSIONS

- PRESENTATION DRAWN FROM CURRENT THRUST OF MPS PROGRAM -- OTHER POSSIBILITIES MAY EXIST, FOR EXAMPLE:
  - VACUUM CAPABILITIES
  - MAKING DEVICES IN SPACE
- STRONGLY URGE THAT STUDY TEAMS INVOLVE MATERIALS SCIENTISTS
- MPS IS CURRENTLY AN INFANT SCIENCE WITH AN ALMOST NON-EXISTANT TECHNOLOGY - POTENTIAL FOR COMMERCIALIZATION IS HIGH, BUT NOT WELL UNDERSTOOD
- COST OF MPS PROCESSING EQUIPMENT IS VERY HIGH -- HOW CAN THIS BE REDUCED?
- MECHANISMS EXIST FOR ENCOURAGING PRIVATE SECTOR PARTICIPATION -- CAN THESE BE IMPROVED?

APPLICATION OF SPACE STATION TO COMMERCIAL COMMUNICATION SATELLITE

JAMES RAMLER

PREPARED FOR

SPACE STATION ORIENTATION BRIEFING

NASA HEADQUARTERS

WASHINGTON, D.C.

SEPTEMBER 14-15, 1982

OUTLINE

- o OVERVIEW OF COMMERCIAL COMMUNICATION SATELLITES
- o SPACE STATION APPLICATION CONSIDERATIONS
- o OBSERVATIONS

FIXED SERVICE

TRUNKING - WIDEBAND (ONE TO ONE OR FEW)
DISTRIBUTION - WIDEBAND (ONE TO MANY)
PRIVATE NETWORK - WIDE AND/OR NARROWBAND (ONE TO ONE OR MANY)

BROADCAST

DIRECT TO HOME - WIDEBAND (ONE TO MANY)
DIRECT TO HOME - NARROWBAND (ONE TO MANY)

MOBILE/TRANSPORTABLE

MARITIME - WIDE OR NARROWBAND
AERONAUTICAL - WIDE OR NARROWBAND
LAND - WIDE OR NARROWBAND

Some pictures and cartoons here to illustrate types of service and satellite types--quick flipthrough

Double projection will be available.
These will not be included in hand-out.

Vu-Graph

1. Trunking Network Service Cartoon (color)
2. Distributed Television Cartoon (color)
3. Satcom Satellite (artist concept - color)
   (Example of state-of-art satellite in Delta class which provides trunking and distributed TV)
4. Intelsat V Satellite (photo - color)
   (Example of state-of-art satellite in Centaur class)
5. Private Network Service Cartoon (color)
6. SBS Satellite (artist concept - color)
   (Example of state-of-art satellite providing private network service)
7. Direct Broadcast Service Cartoon (color)
8. Mobile Satellite Service Cartoon (color)

ORIGINAL PAGE IS
OF POOR QUALITY

SATELLITES IN ORBIT

SATELLITE	NUMBER	SUPPLIER(S)	OWNER/OPERATOR
ANIK (A1-A3,B,C1,D1)	6	HUGHES, RCA, SPAR	TELESAT CANADA
COMSTAR (D1-D4)	4	TRW	COMSAT GENERAL
SATCOM (1,2,3R,4)	4	RCA-ASTRO	RCA-AMERICOM
SBS	2	HUGHES	SATELLITE BUSINESS SYSTEMS
WESTAR (I-V)	5	HUGHES	WU/AMSAT/CONTEL
	21		

ADDITIONAL SATELLITES PLANNED

SATELLITE	NUMBER	SUPPLIER	OWNER/OPERATOR
ALASCOM (SATCOM 5)	1	RCA-ASTRO	ALASCOM INC.
ANIK (C2, C3, D2)	3	HUGHES, SPAR	TELESAT CANADA
GALAXY	2	HUGHES	HUGHES COMMUNICATION
G-STAR	2	RCA-ASTRO	GTE
SATCOM	5	RCA-ASTRO	RCA-AMERICOM
SATMEX	2	TBD	MEXICAN GOVERNMENT
SBS	2	HUGHES	SATELLITE BUSINESS SYSTEMS
SPACENET	3	TBD	SOUTHERN PACIFIC COMM.
TELSTAR	3	TBD	AT&T
WESTAR	1	HUGHES	WU/AMSAT/CONTEL
ADVANCED WESTAR	2	TRW	WU/AMSAT/CONTEL
USAT	2	TBD	U.S. SATELLITE SYSTEMS
ABC	2	TBD	ADVANCED BUSINESS COMM.
RBI	2	TBD	RAINBOW SATELLITE INC.
AMSAT	3	TBD	AMERICAN SATELLITE
WESTERN UNION	3	TBD	WESTERN UNION TELEGRAPH
RCA	3	RCA-ASTRO	RCA-AMERICOM
	41		

SATELLITES PLANNED

(APPLICATIONS ACCEPTED BY FCC FOR LICENSING)

SATELLITE	NUMBER	SUPPLIER	OWNER/OPERATOR
DBSC	3	TBD	DIRECT BROADCAST SATELLITE CORPORATION
RCA	4	RCA-ASTRO	RCA-AMERICOM
WU	4	TBD	WESTERN UNION TELEGRAPH CO.
CBS	4	TBD	COLUMBIA BROADCASTING SYSTEM, INC.
GSC	2	TBD	GRAPHIC SCANNING CORP.
STC	4	TBD	SATELLITE TELEVISION CORP.
USSB	2	TBD	UNITED STATES SATELLITE BROADCASTING CORPORATION
VSS	2	TBD	VIDEO SATELLITE SYSTEMS, INC.
	25		

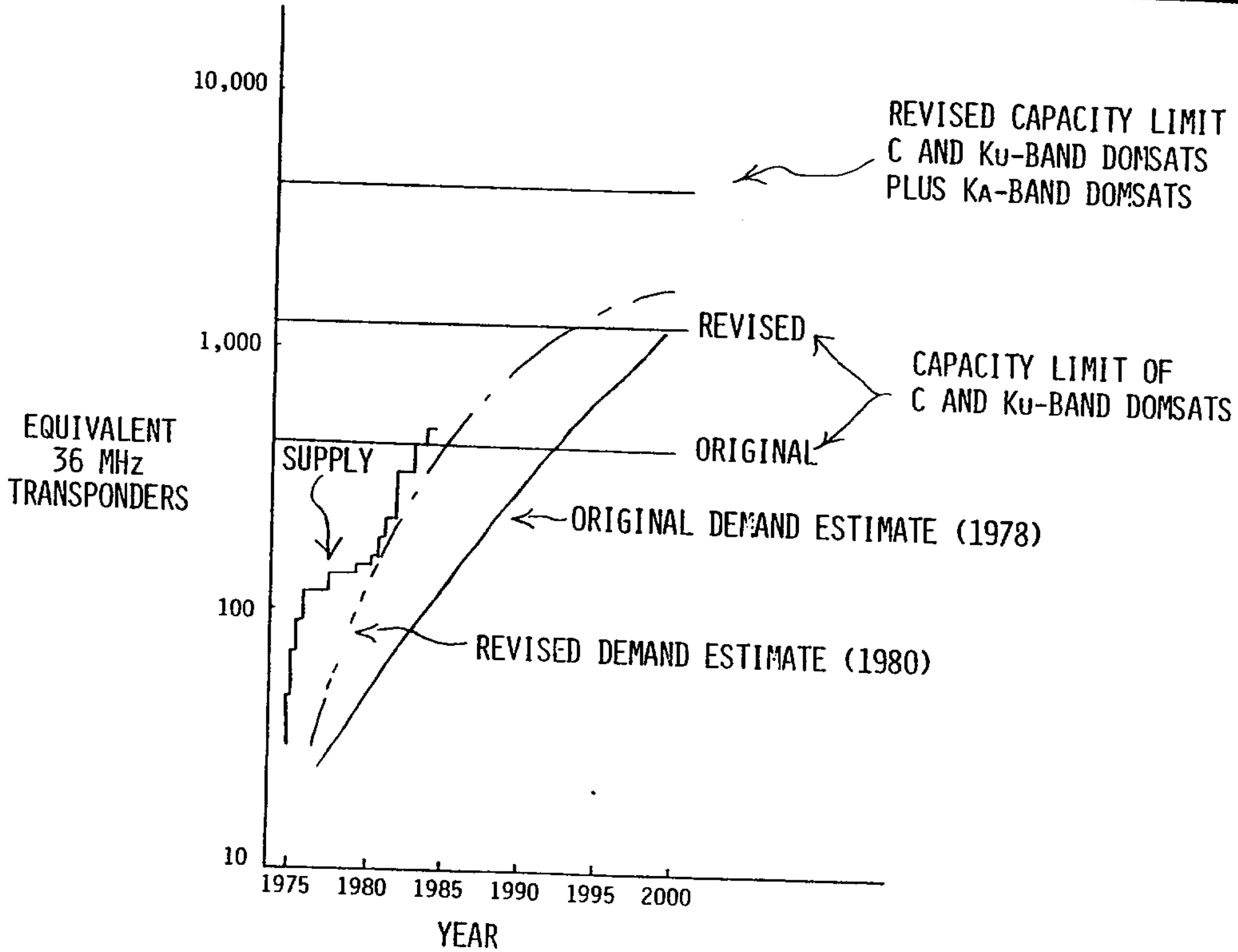
SATELLITE	NUMBER	SUPPLIER	OWNER/OPERATOR
IN-ORBIT			
INTELSAT IV	7	HUGHES	INTELSAT
INTELSAT IV-A	6	HUGHES	INTELSAT
INTELSAT V	9	FORD AEROSPACE	INTELSAT
INTELSAT V-A	5	FORD AEROSPACE	INTELSAT
	27		
PLANNED			
INTELSAT V-A	1	FORD AEROSPACE	INTELSAT
INTELSAT VI	16	HUGHES	INTELSAT
	17		

NASA
Lewis Research Center
SPACE DIRECTORATE

FOREIGN COMMERCIAL COMMUNICATION SATELLITES
FIXED/BROADCAST SERVICE

Date SEPTEMBER 1982

SATELLITE	NUMBER	SUPPLIER(S)	OWNER/OPERATOR
IN-ORBIT			
ITALSAT/SIRCAL	3	CNA	ITALIAN GOVERNMENT
MARECS	2	BAE	EUROPEAN SPACE AGENCY
MARISAT	2	HUGHES	COMSAT GENERAL AND INMARSAT
OTS/ECS	1	HAWKER SIDDELEY	EUROPEAN SPACE AGENCY
PALAPA (A SERIES)	2	HUGHES	INDONESIAN GOVERNMENT/PERUMTEL
INSAT	1	FORD	INDIAN GOVERNMENT
JAPAN BS	1	TOSHIBA/GE	JAPANESE GOVERNMENT
	12		
PLANNED			
ARABSAT	2	AEROSPATIALE/FORD	ARAB SAT COMMUNICATIONS CONSORTIUM
BRAZILSAT	2	SPAR/HUGHES	BRAZILIAN GOVERNMENT (EMBRATEL)
FRANCE TELECOM	2	MATRA	FRENCH GOVERNMENT
JAPAN CS	2	MITSUBISHI/FORD	JAPANESE GOVERNMENT
MARECS	5	BAE	EUROPEAN SPACE AGENCY
PALAPA (B SERIES)	2	HUGHES	INDONESIAN GOVERNMENT/PERUMTER
SATCOL	2	TBD	COLUMBIAN GOVERNMENT
INSAT	2	FORD	INDIAN GOVERNMENT
AUSSAT	3	HUGHES	AUSTRALIAN GOVERNMENT
	22		


10,000
1,000
100
10
EQUIVALENT
36 MHz
TRANSPONDERS
1975
1980
1985
1990
1995
2000
YEAR
REVISED CAPACITY LIMIT
C AND Ku-BAND DOMSATS
PLUS KA-BAND DOMSATS
REVISED
ORIGINAL
CAPACITY LIMIT OF
C AND Ku-BAND DOMSATS
SUPPLY
ORIGINAL DEMAND ESTIMATE (1978)
REVISED DEMAND ESTIMATE (1980)

FORECAST MARKET FOR COMMERCIAL COMMUNICATION SATELLITES (NEW AND REPLACEMENT, 1990 - 2000)

	FIXED SERVICE SATELLITES	BROADCAST SATELLITES	TOTAL SATELLITES
U.S.	$\sim$ 70[1]	15-40[2]	85-110
FOREIGN	$\sim$ 40[1]	10-15[1]	50-55
TOTAL	$\sim$ 110	25-55	135-165

(1) Worldwide Satellite Market Demand Forecast, Western Union

(2) FCC RARC 83 Advisory Committee

TECHNOLOGY EXPERIMENTS/DEVELOPMENT

- o EXAMPLES
  TESTS ASSOCIATED WITH REPAIR, SERVICING AND REFURBISHMENT OF SATELLITES
  INTERSATELLITE LINK SYSTEM TESTS

INITIAL LAUNCH OF SATELLITE

- o CHECKOUT/ASSEMBLY IN LEO
- o MATING TO SPACE-BASED OTV

REPAIR, SERVICING AND REFURBISHMENT

- o IN GEO
- o RETURN TO LEO

- OTV APPROACH AND DOCKING TO COMMUNICATION SATELLITE
- REMOTE MANIPULATOR OR MANUAL WORK STATION APPROACH AND DOCKING
- TESTS OF EQUIPMENT, TOOLS, FLUID TRANSFER SYSTEMS, ETC.
- REPAIR, SERVICING, REFURBISHMENT OPERATIONS TESTS
- TESTS OF SATELLITE DEACTIVATION, STABILIZATION, RESTOWING, ETC.
- MULTIPLE COMMUNICATION PAYLOAD-GEO PLATFORM TESTS (ALL OF ABOVE)

- COMMUNICATION SATELLITES FOR FIXED AND BROADCAST SERVICE ARE LIKELY TO REMAIN "CONVENTIONAL" FOR FORESEEABLE FUTURE
  - -- AVERAGE SIZE WILL GROW BUT LESS THAN FULL SHUTTLE LAUNCH
  - -- DESIGN REDUNDANCY AND GROUND TESTING WILL LIKELY REMAIN AT TODAY'S LEVEL EVEN WITH IN-ORBIT SERVICING AND REPAIR
  - -- LIFETIME WILL GROW WITH TECHNOLOGICAL IMPROVEMENTS; 10 YEARS IS STATE-OF-ART
  - -- NO EXTREMELY LARGE ANTENNAS (PERHAPS 30 FEET MAXIMUM DIAMETER)

- COMMUNICATION SATELLITES FOR NARROWBAND BROADCAST OR MOBILE SERVICE WILL BE "UNCONVENTIONAL"
  - -- SIZE REQUIRES FULL SHUTTLE LOAD OR LARGER
  - -- DESIGN DOMINATED BY LARGE ANTENNA (50-200 M)
  - -- LARGE POWER SYSTEM (10-20 KW ARRAY)

- CHECKOUT IN LEO OF "CONVENTIONAL" SATELLITES FOR FIXED AND BROADCAST SERVICE DOES NOT APPEAR ADVANTAGEOUS OR DESIRABLE TO INDUSTRY

- SATELLITES FOR NARROWBAND BROADCAST OR MOBILE MAY OFFER OPPORTUNITY FOR LEO CHECKOUT AND PERHAPS ASSEMBLY DUE TO EXTREMELY LARGE STRUCTURE

- SPACE-BASED OTV WOULD OFFER OPPORTUNITY TO INCREASE COMMUNICATION SATELLITE TRAFFIC TO SPACE STATION

- ECONOMICS AND RISK IS PARAMOUNT (AS PERCEIVED BY OWNERS/OPERATORS/BUILDERS)

  -- IMPACTS ON SATELLITE DESIGN AND COST
  -- COST OF CHECKOUT/ASSEMBLY
  -- BENEFITS VERSUS COSTS
  -- RISKS

Artist concepts of mobile-satellite and narrowband direct broadcast satellite will be shown here to illustrate the large structure

Vu-graph

1. Mobile-Satellite Configuration (color)
2. Narrowband Direct Broadcast Configuration (color)

DONE IN GEO (UNMANNED)

-- OTV TRANSPORTS EQUIPMENT, TOOLS, REPLACEMENT PARTS, FLUIDS, REMOTE TELEOPERATED SYSTEM
-- OTV RENDEVOUS WITH SATELLITE
-- SATELLITE DEACTIVATED AND STABILIZED
-- REMOTE TELEOPERATED SYSTEM CAPTURES AND DOCKS WITH SATELLITE
-- SATELLITE DESIGN MUST ACCOMMODATE

DONE IN LEO (MANNED OR UNMANNED)

-- OTV RENDEVOUS, APPROACH, CAPTURE, DOCK WITH SATELLITE AND RETURN TO LEO
-- MEN AND EQUIPMENT/TOOLS AVAILABLE IN LEO--SHOULD SIMPLIFY OPERATIONS AND COMPLEXITY/SOPHISTICATION OF REMOTE CONTROL EQUIPMENT
-- MUCH OF EQUIPMENT/TOOLS REQUIRED IN LEO ALREADY DEVELOPED OR WILL BE DEVELOPED IN SHUTTLE PROGRAM
-- REQUIREMENTS ON SATELLITE DEACTIVATION, ETC., APPEAR TO BE SIMILAR TO SERVICING IN GEO
-- REPLACEMENT PARTS AND SUPPLIES DON'T NEED TRANSPORT TO GEO

- IS IT FEASIBLE?
  - -- IMPACTS ON SATELLITE DESIGN
  - -- IMPACTS ON COMMUNICATION SERVICES
  - -- IMPACTS ON OTV DESIGN
  - -- EQUIPMENT, TOOLS, CONTAINERS, ETC., REQUIRED
  - -- OPERATIONAL COSTS
  - -- RISKS
- LEO VERSUS GEO REPAIR NEEDS CAREFUL STUDY
- WHAT UNIQUE CAPABILITIES TO SUPPORT REPAIR, SERVICING, REFURBISHMENT WILL SPACE STATION OFFER OVER SHUTTLE?
- WOULD SATELLITE OWNER/OPERATORS DO IT?
  - -- PERCEIVED BENEFIT VERSUS COST
  - -- PERCEIVED RISK

- ECONOMICS AND RISK AS PERCEIVED BY SATELLITE OWNER/OPERATORS WILL BE PARAMOUNT IN DETERMINING SPACE STATION REQUIREMENTS FOR SUPPORTING COMMERCIAL COMMUNICATION SATELLITES.

- VALUE TO INDUSTRY OF LEO CHECKOUT OF "CONVENTIONAL" FIXED SERVICE AND BROADCAST SATELLITES HAS NOT BEEN ESTABLISHED.

- POTENTIAL NARROWBAND MOBILE AND BROADCAST SATELLITES USING EXTREMELY LARGE ANTENNAS AND SOLAR ARRAYS OFFER BEST POTENTIAL FOR LEO CHECKOUT AND PERHAPS ASSEMBLY.

- SERVICE, REPAIR AND REFURBISHMENT OF COMMUNICATION SATELLITES, PARTICULARLY THOSE WITH HIGH INVESTMENT COST WOULD APPEAR TO HAVE MORE POTENTIAL THAN LEO CHECKOUT--BUT AGAIN, FEASIBILITY NEEDS TO BE ESTABLISHED.

- TECHNOLOGY EXPERIMENTS/TESTS RELATIVE TO IN-ORBIT CHECKOUT/ASSEMBLY, REPAIR, SERVICING OR REFURBISHMENT OF SATELLITES OFFER A POTENTIAL APPLICATION FOR SPACE STATION SUPPORT.

- IF SPACE-BASED OTV IS FEASIBLE, IT WOULD APPEAR TO OFFER BEST OPPORTUNITY FOR SPACE STATION SUPPORT OF COMMUNICATION SATELLITES.

- SPACE STATION ADVANTAGES FOR SUPPORTING THESE ACTIVITIES VIS-A-VIS THE SHUTTLE NEED TO BE ESTABLISHED.

COMMERCIALIZATION PROSPECTS FOR REMOTE SENSING FROM A NATIONAL SPACE STATION

WILBUR ESKITE

NOAA/NESS

PRESENT BARRIERS TO COMMERCIAL SATELLITE REMOTE SENSING IS PRIMARILY FINANCIAL.

IF FINANCIAL BARRIERS COULD BE ALLEVIATED,
POLICY CONSTRAINTS COULD BE REMOVED.

Possible Space Station Contributions to Commercial Remote Sensing

- o Observing Platform
- o Satellite Service Facility
- o Hard Copy Return

Major Remote Sensing Disciplines

- o Weather and Climate
- o Oceanographic
- o Land and Its Resources

Weather and Climate
Techniques, Requirements and Needs

- Present Techniques
- Requirements
- Unmet Needs

WEATHER AND CLIMATE
COMMERCIALIZATION CONSIDERATIONS

- SYSTEMS HANDLED INTERNATIONALLY BY GOVERNMENTS
- FREE INTERNATIONAL EXCHANGE OF DATA
- REMOTE DATA HANDLED LIKE ALL OTHERS
- LONG HISTORY OF FREE EXCHANGE

QUESTIONABLE REAL COMMERCIAL POTENTIAL.

OCEANOGRAPHIC

TECHNIQUES, REQUIREMENTS AND NEEDS

- PRESENT AND PAST TECHNIQUES
- REQUIREMENTS
- UNMET NEEDS

Oceanographic Sensing

Commercialization Considerations

- o Limited Availability of Remotely Sensed Data
- o Initial Primary Use by Federal Government (NOAA/NAVY)
- o Possible Commercial Fishery Use of Color Scanner
- o Possible Commercial Use of SAR (Sea State for Navigation)
- o Present Commercial Use of Gulf Stream Analysis (Shipping) (Obtained by MetSats)

Possible Commercial Use is Potentially Large.

Land Sensing

- Renewable Resources Applications
- Non-Renewable Resources and other Geologic Applications
- Other Applications

Land and Its Resources
Techniques, Requirements and Needs

- Techniques
- Renewable Resources
  - Requirements
  - Unmet Needs
- Non-Renewable Resources
  - Requirements
  - Unmet Needs
- Other
  - Requirements
  - Unmet Needs

Land Sensing - Renewable Resources
Commercialization Considerations

- Major User - U.S. Government (Agriculture)
- Possible Commercial Users
  1. Forest Management
  2. Crop Management
  3. Water Management
  4. Disease and Insect Detection
  5. Commodity Speculation

Medium to High Potential Commercial Use.

LAND SENSING NON-RENEWABLE RESOURCES
COMMERCIALIZATION CONSIDERATIONS

- o SMALL GOVERNMENT REQUIREMENT
- o POSSIBLE COMMERCIAL USERS
  - \- PETROLEUM INDUSTRY
  - \- MINERAL EXTRACTION INDUSTRY

HIGH POTENTIAL COMMERCIAL USE.

Land Sensing - Other
Commercialization Considerations

- o Virgin Areas
  - Demographics
  - Land Use and Planning
  - Etc.
- o Primarily Commercial, State and Local, and International Users

Commercial Potential Depends on Major Development.

Space Station Unique Advantages

- Low Cost Single Purpose Platforms
- Space Repairable
- Orbit Flexibility and Changeable

Possible Technique Development Required for Space Station Utilization

- Space Repairable Modular Spacecraft
- Low Cost Single Purpose Spacecraft
- Tetherable Spacecraft

ROLE OF MAN IN SPACE
IN REMOTE SENSING

- SPACECRAFT REPAIR
- TARGETS OF OPPORTUNITY

Illustrated Slides

1. NOAA Polar Orbiting Satellite
2. Typical NOAA Satellite Product
3. GOES Geostationary Satellite
4. Typical GOES Satellite Product
5. SEASAT Satellite
6. Typical SEASAT Satellite Product
7. Typical Coastal Zone Color Scanner Product
8. LANDSAT Satellite
9. Typical LANDSAT MSS Product for Agriculture
10. Typical LANDSAT MSS Product for Mineral Exploration
11. Typical LANDSAT TM Product for Demographic Purposes

III INTERNATIONAL STUDIES

E. BRIAN PRITCHARD, MODERATOR

SPACE STATION TASK FORCE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

III. a) ESA PROGRAM

M. JACQUE COLLET

EUROPEAN SPACE AGENCY

ESA PREPARATORY PROGRAMME FOR LONG-TERM SPACE TRANSPORTATION SYSTEM

OBJECTIVE : PREPARE DECISION FOR MID-1980'S ON SPACE TRANSPORTATION SYSTEMS-ELEMENTS BEYOND ARIANE IV AND SPACELAB/EURECA.

3 THEMES :

- FUTURE EUROPEAN LAUNCHER
- EUROPEAN IN-ORBIT INFRASTRUCTURE
- CONTINUATION OF TRANSATLANTIC COOPERATION IN FUTURE U.S. SPACE STATION PROGRAMME.

STATUS : OBJECTIVES AND CONTENTS OF PREPARATORY PROGRAMME AMONGST INTERESTED EUROPEAN MEMBER STATES AGREED UPON. FAVOURABLE DECISION ON BUDGET OF 12 MAU FOR PERIOD 1983 - 1985 EXPECTED.

FUTURE EUROPEAN LAUNCHER

OBJECTIVE : PROVIDE LAUNCH CAPABILITY THAT MEETS FORESEEABLE EUROPEAN REQUIREMENTS IN COST-EFFECTIVE MANNER.

STUDIES : SYSTEM STUDY WITH INTERNATIONAL EUROPEAN STUDY TEAM UNDER LEAD OF SNIAS UNDERWAY.

- DEFINE LAUNCHER CONCEPTS BEYOND AR-4, IDENTIFY CRITICAL TECHNOLOGIES AND STUDY SELECTED CONCEPTS IN DETAIL.
- STUDY ROCKET ENGINES FOR FUTURE LAUNCHER.
- HM60 WORK PARTICIPATION.

EUROPEAN IN-ORBIT INFRASTRUCTURE (IOI)

- AUTOMATED LOW EARTH ORBIT PLATFORMS DERIVED FROM EURECA, REQUIRING :
  - RENDEZ-VOUS AND DOCKING CAPABILITY
  - ROBOTICS/TELEMANIPULATION
  - RESUPPLY/LOGISTICS VEHICLES
  - ULTIMATELY RETURN CAPABILITY

- TWO IOI STUDIES UNDERWAY.

  CONTINUATION IN 1983 FORESEEN.

CONTINUATION OF TRANSATLANTIC COOPERATION IN FUTURE U.S. SPACE STATION PROGRAMME

Date

OBJECTIVE : STUDY REQUIREMENTS FOR UTILISATION, CONTENTS OF POSSIBLE EUROPEAN-PROVIDED ELEMENTS AND CONDITIONS OF COOPERATION.

STUDIES :

- STUDY ON EUROPEAN UTILISATION ASPECTS OF A U.S. MANNED SPACE-STATION UNDERWAY WITH DFVLR + EUROPEAN INDUSTRY.

- PARTICIPATION OF EUROPEAN INDUSTRY TO NASA SPACE STATION STUDIES IN PROCESS OF EVALUATION.

Date ....

E U R E C A

(EURECA RETRIEVABLE CARRIER)

PROGRAMME OBJECTIVES (I)

o TO PROVIDE A PAYLOAD CARRIER WHICH CAN BE SEPARATED FROM THE SHUTTLE IN ORBIT, OPERATE IN A FREE-FLYING MODE, BE RETRIEVED TOGETHER WITH ITS PAYLOAD, AND BE REUSED.

A MICROGRAVITY PAYLOAD IS PROPOSED AS PRIMARY PAYLOAD, WHICH WILL INFLUENCE THE CARRIER DESIGN DUE TO ITS HIGH POWER AND LOW ACCELERATION REQUIREMENTS.

o TO OFFER THE USERS THE COMBINED ADVANTAGES OF SPACELAB AND A CONVENTIONAL FREE-FLYING SATELLITE :

- ADEQUATE MASS- AND POWER ALLOCATION
- EXTENDED OPERATION TIME
- OPTIMIZED ORBIT
- 'CLEAN' ENVIRONMENT
- GOOD POINTING ACCURACY AND STABILITY

EURECA KEY DATA (MICROGRAVITY MISSION)

- LAUNCH/RETRIEVAL BY SHUTTLE : PERIOD END 1986/MID 1987
- ORBIT : DEPLOYMENT/RETRIEVAL 300 KM, 28.5° INCLINATION
  OPERATIONAL 500 KM, 28.5° INCLINATION
  LIFETIME (DECREASE TO 300 KM ALTITUDE) LONGER THAN 1/2 YEAR
- MISSION DURATION : TOTAL 6 MONTHS; ACTIVE EXPERIMENT OPERATION APPROX. 4 MONTHS.
- OPERATIONAL ALTITUDE : SOLAR INERTIAL
- MICROGRAVITY CONDITIONS FOR EXPERIMENTS : 10^{-5} G
- PAYLOAD MASS : APPROX. 1000 KG
- PAYLOAD LENGTH : APPROX. 2000 MM, INCLUDING DYNAMIC CLEARANCE (POSSIBILITY TO REDUCE TO 1700 MM UNDER INVESTIGATION TO SAVE MISSION COST)
- S-BAND TO ESA GROUND STATIONS DURING MISSION OPERATIONS
- PROPULSION SYSTEM FOR CHANGE OF ORBIT ALTITUDE AND LIMITED MANOEUVRE CAPABILITY
- COLD GAS OR REACTION WHEEL ATTITUDE CONTROL SYSTEM
- DEPLOYABLE/RETRACTABLE SOLAR ARRAYS

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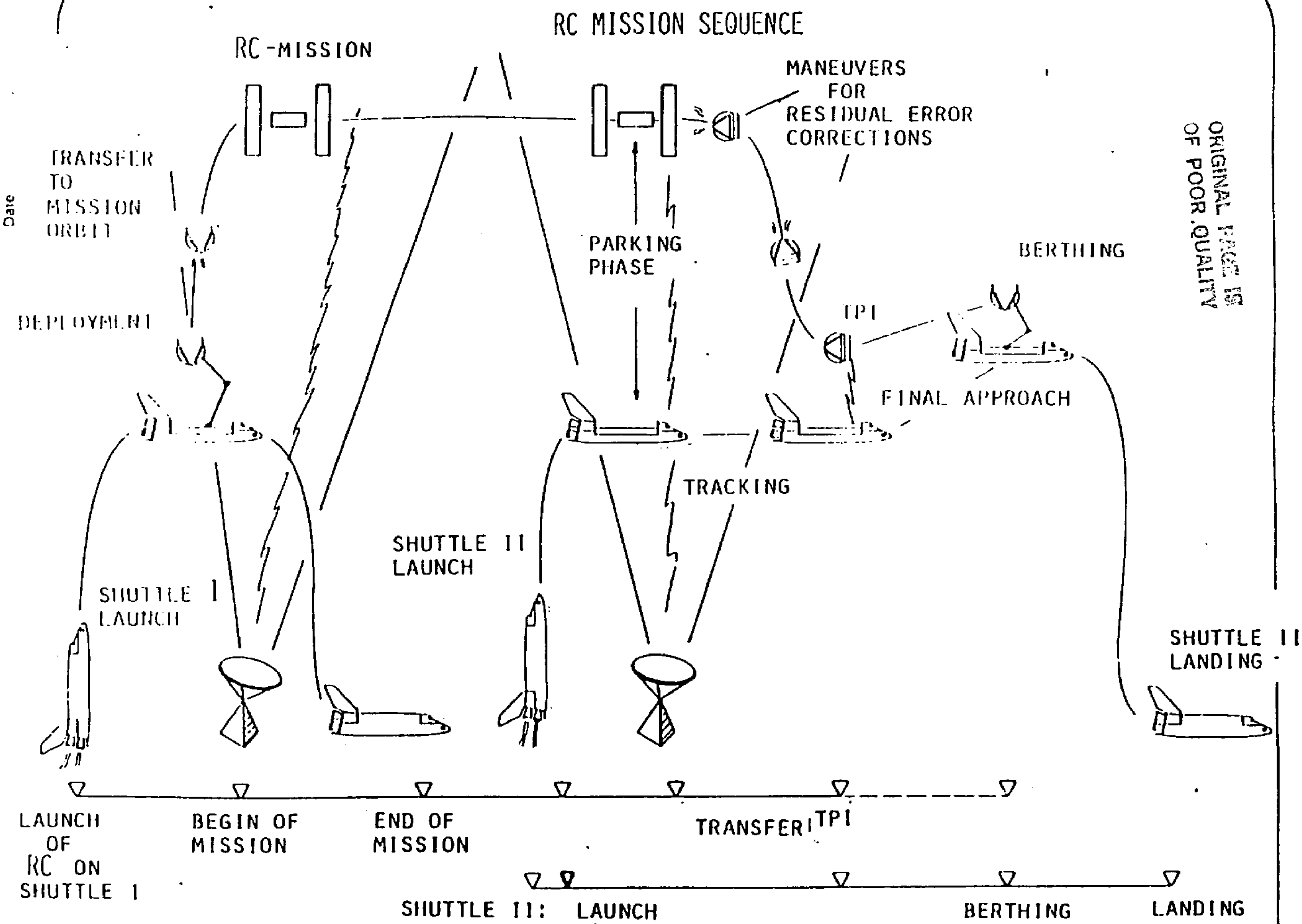

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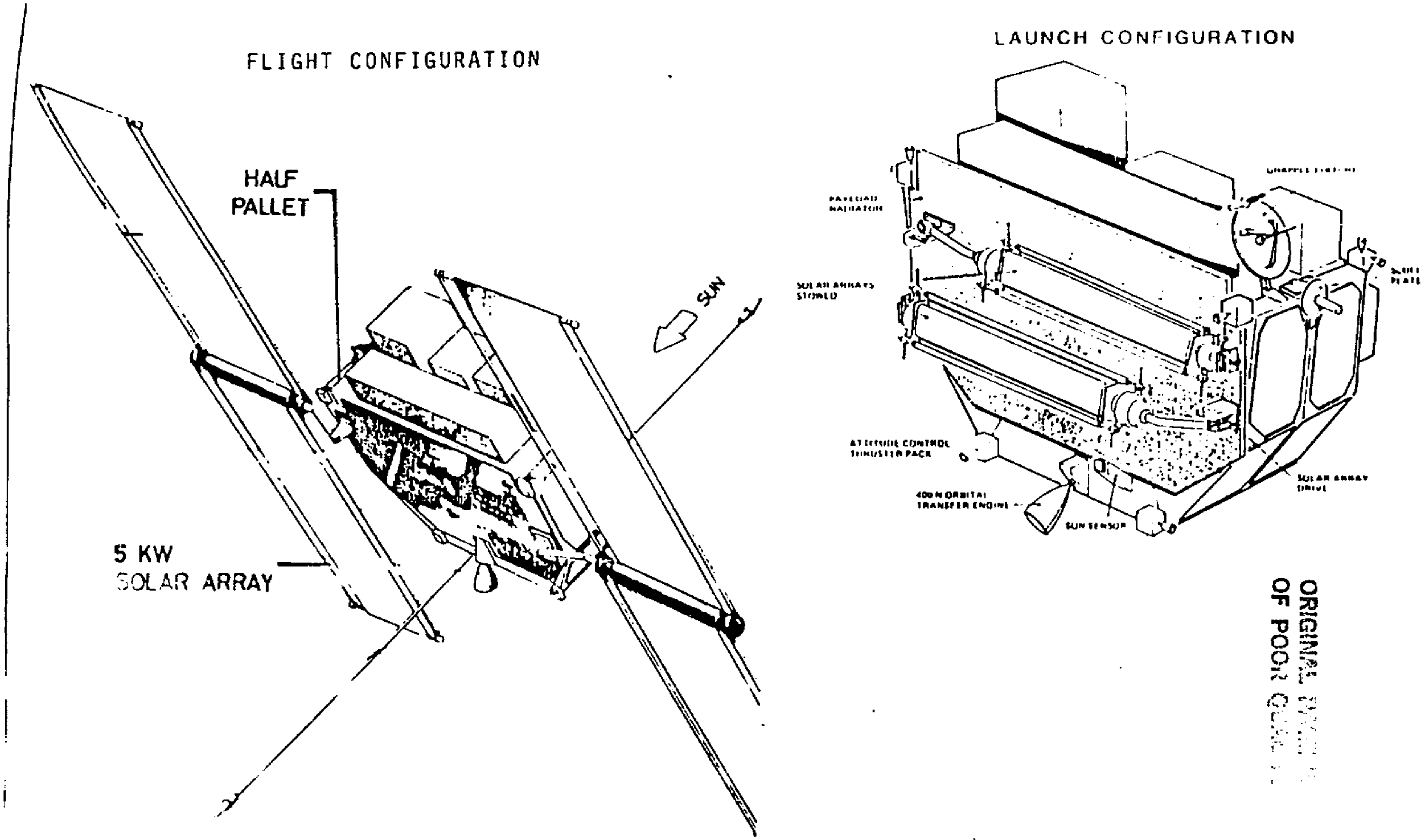
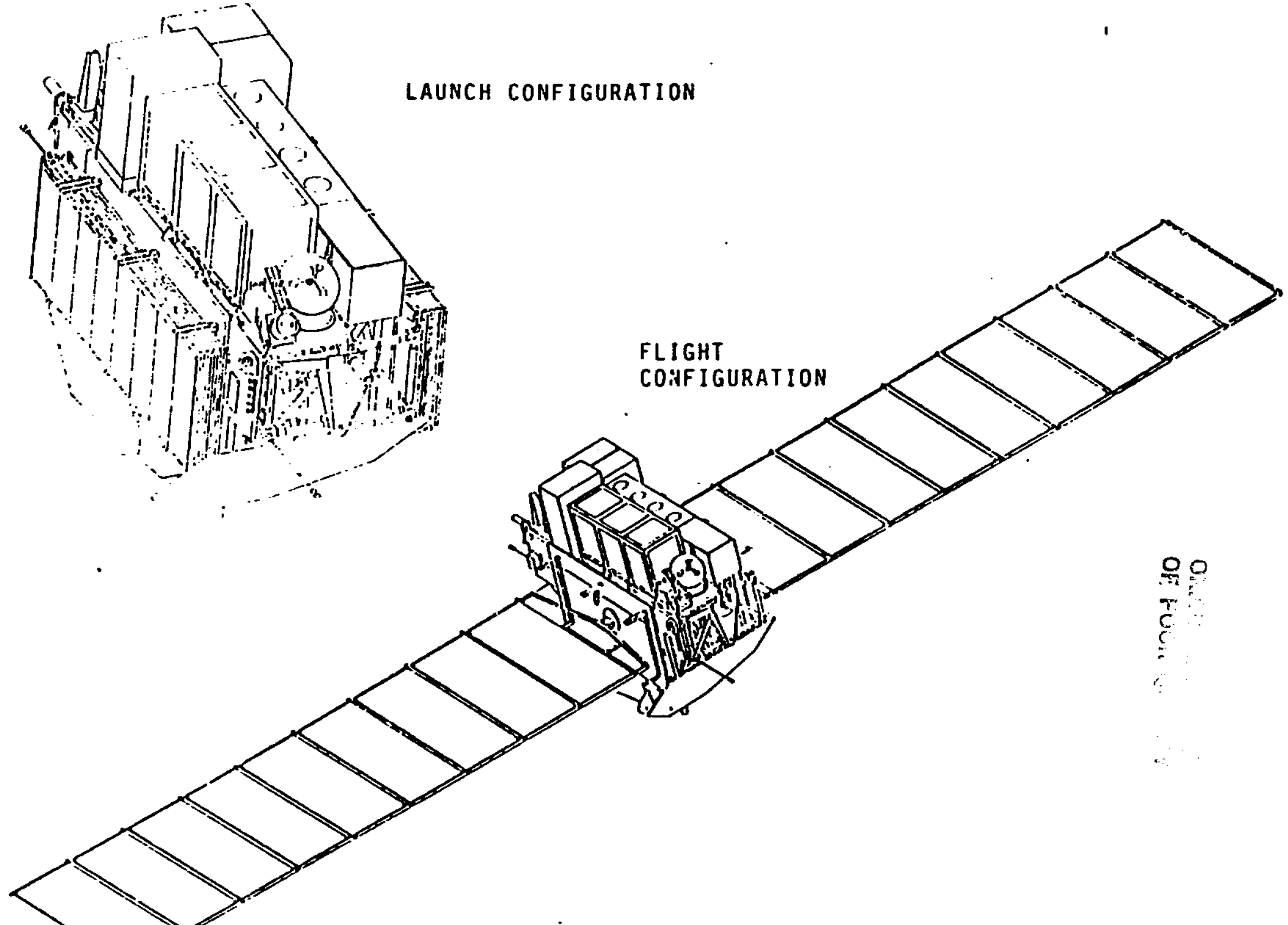
MODEL PAYLOAD

	EXPERIMENT/FACILITY	MASS (KG)	SIZE (M)	POWER (W)
1	MIRROR HEATING FACILITY	$\approx$150 (?)	$\approx$0.8x0.8x0.8	$\approx$ 500
2	SOLUTION GROWTH FACILITY	$\approx$150	$\approx$1.5x1.0 0.5	$\approx$ 50
3	PROTEIN GROWTH FACILITY	$\approx$ 60	$\approx$0.4x0.6x02	$\approx$ 80
4	MULTI FURNACE ASSEMBLY	x	x	x
5	AUTOMATIC GRADIENT HEATING FACILITY	$\approx$175	$\approx$1.0x0.9x0.5	$\approx$ 800
6	PLANT/PROTISTA FACILITY	$\approx$100	$\approx$1.0x0.5x0.5	$\approx$ 50
7	SOLAR CONSTANT	7	0.5x0.2x0.2	5
8	SOLAR SPECTRUM	33	0.6x0.4x0.3	150
9	ELECTRIC PROPULSION	25	0.9x0.6x0.4	400

x DEPENDS ON NUMBER OF FURNACES



[illegible] UNCH CO[illegible]GURATION FOR E U R [illegible] C A BASED
ON THE SPACELAB PALLET STRUCTURE (BAE)



FLIGHT AND LAUNCH CONFIGURATION OF E U R E C A BASED ON THE SPAS-STRUCTURE (MBB)

TYPICAL MASS AND POWER BUDGET FOR E U R E C A

MASS BUDGET

STRUCTURE (PRIMARY & SECONDARY)	570 KG
THERMAL CONTROL	205 KG
POWER (INCL. SA & BATTERIES)	350 KG
DATA HANDLING	20 KG
ATTITUDE & ORBIT CONTROL	200 KG
TELEMETRY/TELECOMMAND	20 KG
HARNESS	150 KG
MISCELLANEOUS I/F HARDWARE	50 KG
PLATFORM DRY WEIGHT	1 565 KG
15 % SYSTEM MARGIN	235 KG
PROPELLANT	465 KG
REFERENCE PAYLOAD	1 295 KG
TOTAL LAUNCH WEIGHT	3 560 KG

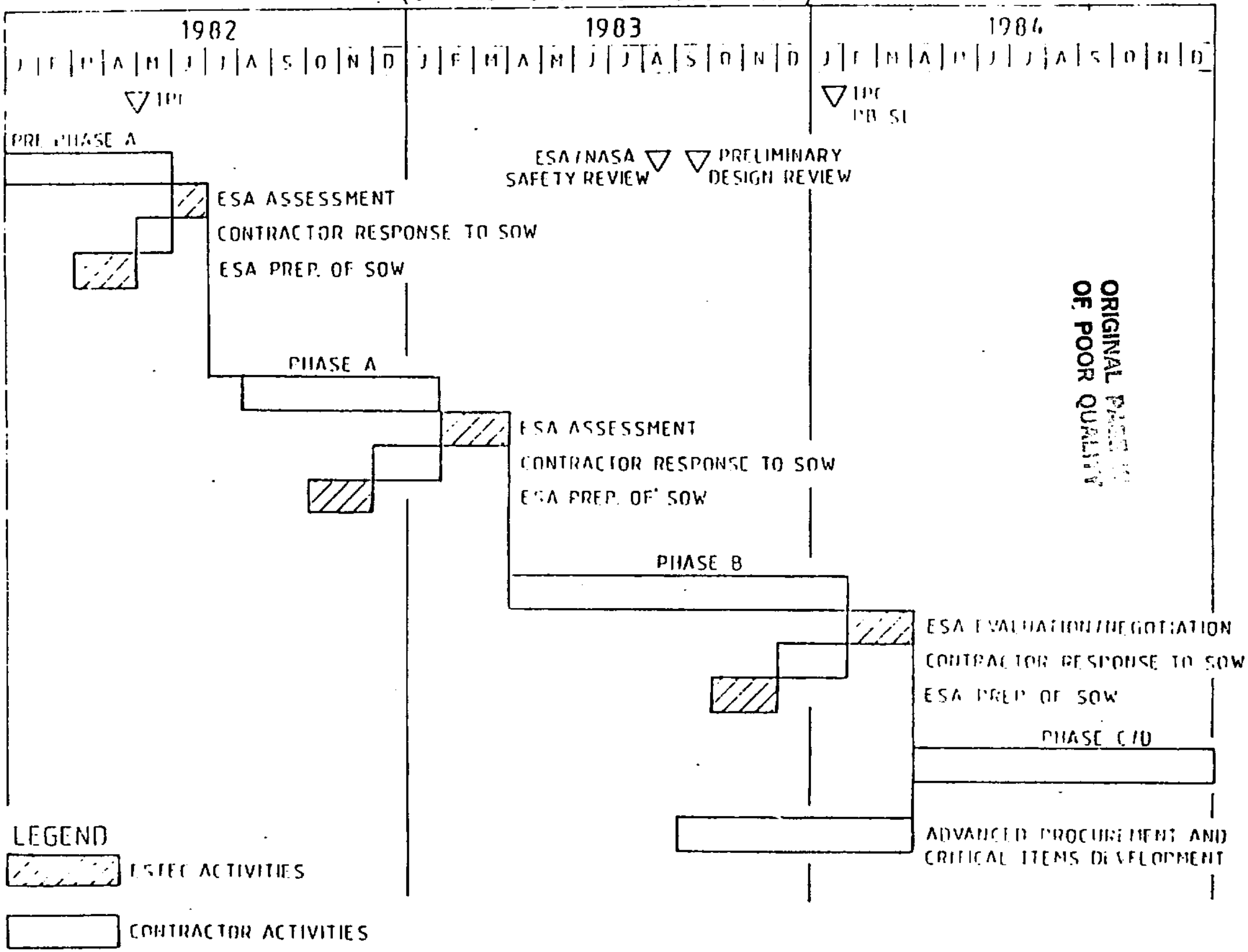
POWER BUDGET

	ALL LIQUID LOOP COOLING		ALL HEAT PIPE COOLING	
	DAYLIGHT	ECLIPSE	DAYLIGHT	ECLIPSE
THERMAL CONTROL	420	420	180	180
POWER CONDITIONING	200	200	200	200
DATA HANDLING & HOUSEKEEPING	70	70	70	70
ORBIT PROPULSION/ATTITUDE CONTROL	55	55	55	55
TELEMETRY/TELECOMMAND	60	60	60	60
HARNESS LOSS	40	40	40	40
CARRIER SUBSYSTEM	845	845	605	605
BATTERIE CHARGING	1900	-	1900	-
PAYLOAD ALLOCATION	1600	1600	1600	1600
EURECA SYSTEM	4345	2445	4105	2205
SYSTEM MARGIN 10%	434	244	410	220
MARGIN AGAINST RESTRUNG ST ARRAY FOR FIRST MISSION	4779	2685	4515	2425
BOL 5300 W	521 *	-	785	-
EOL 5000 W				

* Margin during sunlight phase equivalent to about 300 W continuous

PROPOSED PHASED DEVELOPMENT PLANNING FOR 'EURECA'

(STATUS AS OF 13TH JULY 1982)



III. a) STUDY ON EUROPEAN UTILIZATION ASPECTS OF A U.S. MANNED SPACE STATION

DR. W. LEY

DFVLR

GERMANY

STUDY ON

EUROPEAN UTILISATION ASPECTS

OF A

U.S. MANNED SPACE STATION

ESA No. AO/1-1.453/82/F

STUDY MANAGER : DR. W. LEY / DFVLR
GERMANY

REVIEW OF SPACE STATIONS CONCEPT WP 1000

— IDENTIFICATION AND PROCUREMENT OF RELEVANT DOCUMENTS WP 1100

— DOCUMENTS REVIEW ; ANALYSIS OF DIFFERENT STATION APPROACHES WP 1200

— SYNTHESIS : DISCUSSION OF SPACE STATION POTENTIAL WP 1300

8.9.82 — 15.10.82

5 WEEKS

IDENTIFICATION AND ANALYSIS OF EUROPEAN MISSION CANDIDATES — WP 2000

- MATERIAL SCIENCES AND PROCESSING — WP 2100
- LIFE SCIENCES — WP 2200
- SPACE SCIENCES AND APPLICATION — WP 2300
- SPACE TECHNOLOGY AND OPERAT. SUPPORT — WP 2400
- NEW SPACE UTILISATION FIELDS — WP 2500

15.9.82 — 19.11.82 - - - - - - - - - -

9 WEEKS — continuing

STUDY OBJECTIVES AND SCOPE

— ELABORATE A FIRST ASSESSMENT OF THE EUROPEAN INTEREST IN UTILIZING A MANNED SPACE STATION

— IDENTIFY EUROPEAN PAYLOAD CANDIDATES WHICH CAN BE BENEFICIALLY SUPPORTED BY A MANNED SPACE STATION AND WILL ASSESS THE REQUIRED OPERATIONAL SPACE STAT. SUPPORT

— ALTERNATIVE APPROACHES - AS NO MANNED RESPECTIVE NO SPACE STATION AVAILABLE. IDENTIFY IMPACT.

— BENEATH "CLASSIC DISCIPLINES" NEW SPACE OPPORTUNITIES

— IDENTIFY NEW POTENTIAL USERS

REQUIREMENTS ANALYSIS OF PAYLOAD CANDIDATES — WP 3000

SELECTION OF REPRESENTATIVE PAYLOAD CANDID. WP 3100

EVALUATION OF FLIGHT DYNAMICS REQUIREMENTS WP 3200

EVALUATION OF ACCOMODATION REQUIREMENTS WP 3300

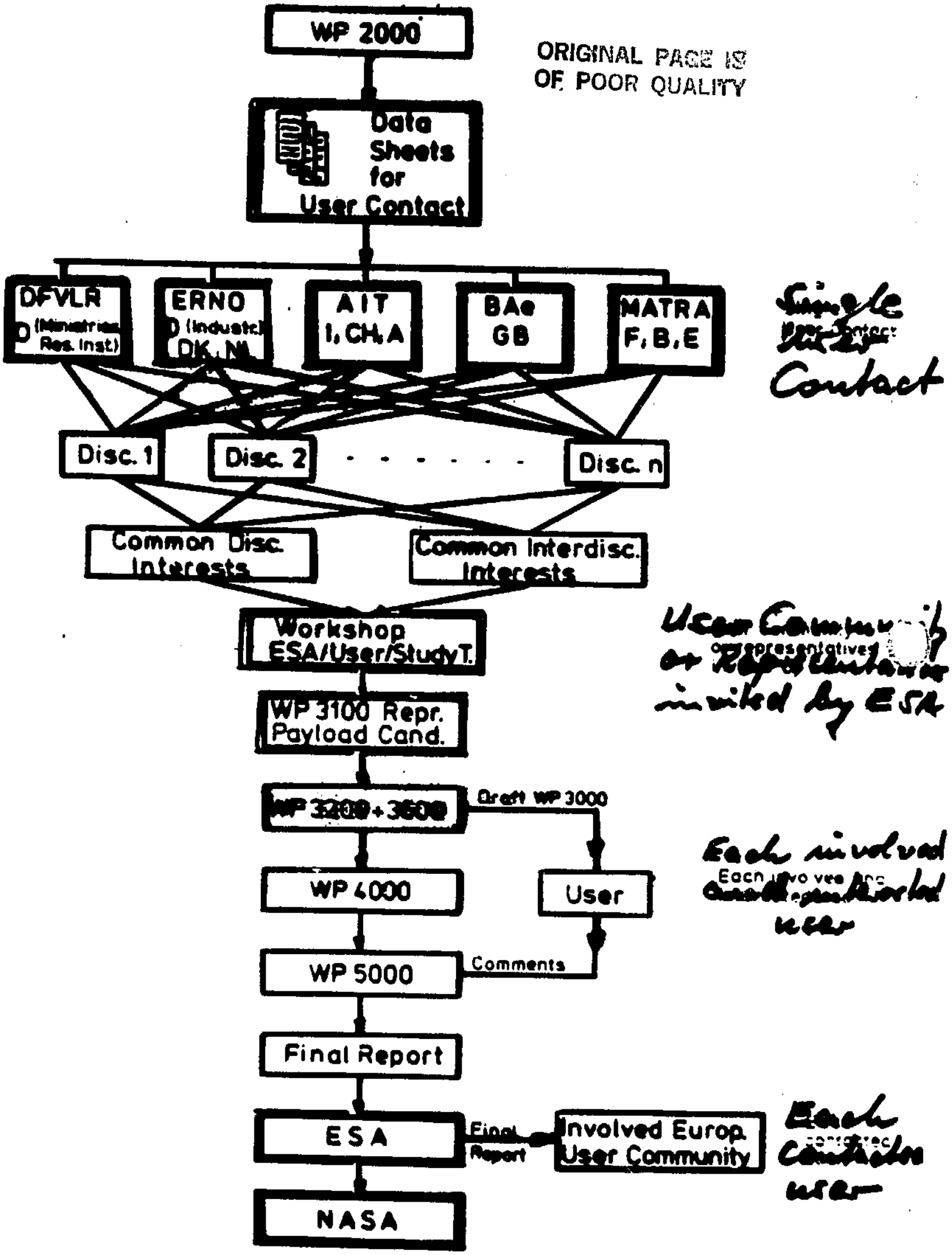
EVALUATION OF FLIGHT OPERATION REQUIREMENTS WP 3400

ANALYSIS OF COMMAND AND DATA REQUIREMENTS WP 3500

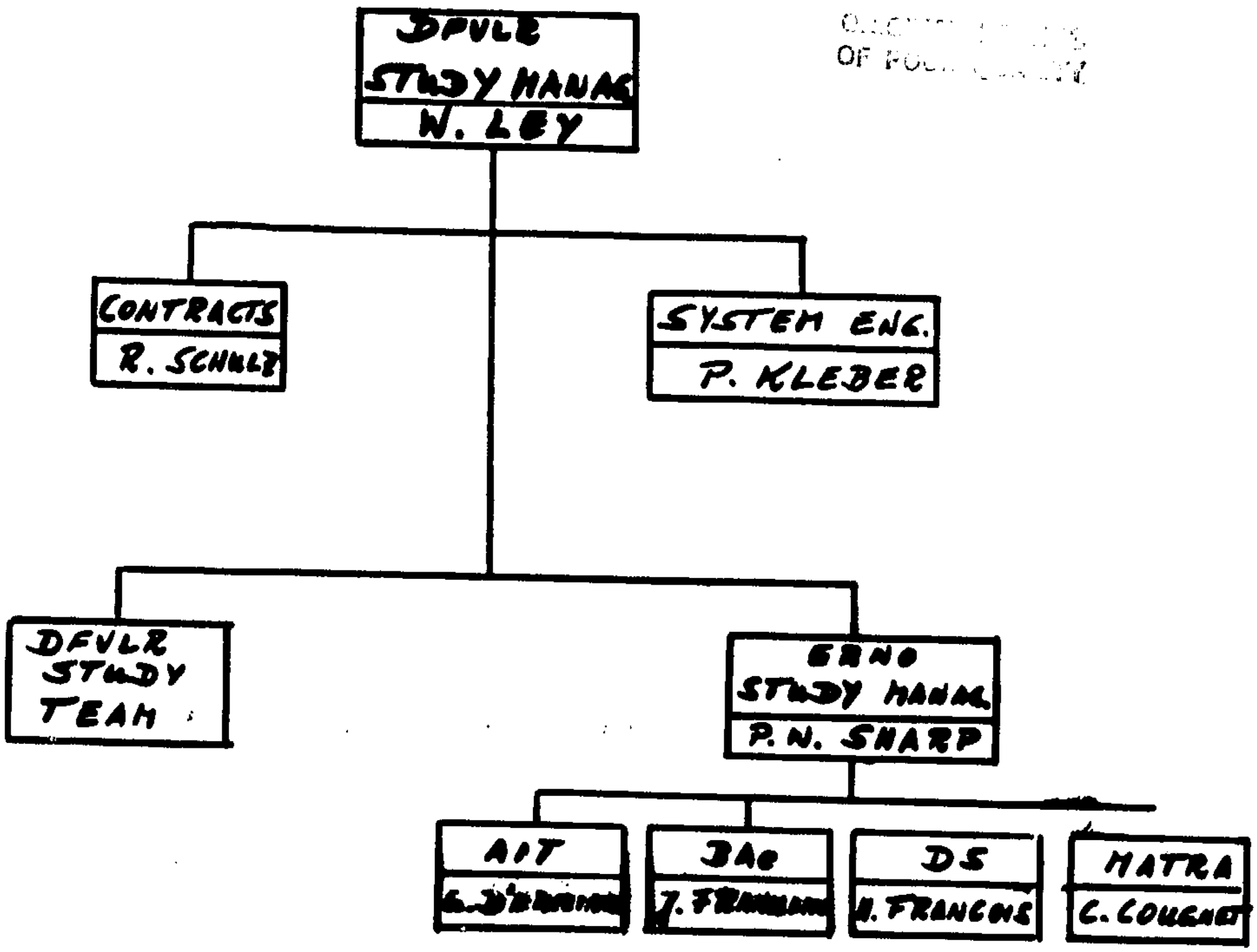
SYNTHESIS: DEFINITION OF COMMON AND OVERALL REQUIREMENTS WP 3600

9.11.82 — 21.1.83

7 WEEKS



User Involvement in EUA-Study



STUDY ORGANISATION

National Research Council Canada
Conseil national de recherches Canada

III. b) CANADIAN PARTICIPATION IN A SPACE STATION PROGRAM

K.H. DOETSCH

NATIONAL AERONAUTICAL ESTABLISHMENT
NATIONAL RESEARCH COUNCIL OF CANADA

SPACE STATION PROGRAM

BACKGROUND

- CANADA HAS A LONG TRADITION OF INVOLVEMENT IN SPACE ACTIVITY AND IN COOPERATIVE PROGRAMS
  - COMMUNICATIONS
    - EARLY BIRD
    - INTELSAT SERIES
    - ANIK SERIES
    - SARSAT
    - HERMES
    - M SAT
  - REMOTE SENSING
    - LANDSAT
    - SURSAT
    - RADARSAT
    - ERS-1
  - NAVIGATION
    - AEROSAT
  - SCIENCE
    - ALOUETTE I, II
    - ISIS I, II
  - TECHNOLOGY
    - CANADARM

BACKGROUND (CONT'D)

- CANADA HAS BEEN ACTIVE BOTH AS A USER AND AS A SUPPLIER OF SPACE SERVICES AND HARDWARE
- CANADA HAS AN INTEREST IN DEVELOPING BOTH ASPECTS IN THE NEXT PHASE OF THE EVOLUTION AND TECHNICAL EXPLOITATION OF SPACE
- SPACE STATIONS PERMANENTLY IN LOW EARTH ORBIT ARE CONSIDERED TO BE THE NEXT LIKELY MAJOR DEVELOPMENT IN THE EXPLOITATION OF SPACE

National Research Council Canada | Conseil national de recherches Canada

Space Station Briefing
NASA HQ.
13 - 15 Sept. '82
Sheet 4

SPACE STATION PROGRAM - CANADIAN PARTICIPATION

EVALUATION PHASE

- A JOINT GOVERNMENT - INDUSTRY STUDY HAS BEEN INITIATED TO EVALUATE THE BENEFITS TO CANADA OF PARTICIPATION IN PROGRAM(S) FOR THE DEVELOPMENT OF PERMANENT SPACE STATIONS OR PLATFORMS IN LOW EARTH ORBIT

- STUDY INCLUDES:
  - USER REQUIREMENTS DEFINITION
  - TECHNOLOGY DEVELOPMENT ASSESSMENT
  - COST/BENEFITS ANALYSIS
  - ALTERNATIVES ASSESSMENT
  - PARALLEL STUDIES MONITORING

- STUDY START AUG. 1982
- INTERIM REPORT NOV. 1982
- FINAL REPORT JULY 1983

National Research Council Canada / Conseil national de recherches Canada

Space Station Briefing
NASA HQ.
13 - 15 Sept. '82
Sheet 5

USER REQUIREMENTS

- IDENTIFY POTENTIAL USERS AND EXPECTED BENEFITS TO USERS
  - INDUSTRIAL
  - SCIENTIFIC
  - GOVERNMENT
- ESTABLISH USER REQUIREMENTS
- PREPARE SUMMARY REPORT

TECHNOLOGY DEVELOPMENT ASSESSMENT

- ESTABLISH TECHNOLOGY AREAS SUITABLE FOR CANADIAN DEVELOPMENT
  - SPACE MECHANISMS
  - SPACE STRUCTURES
  - EARTH SENSORS/SENSOR SYSTEMS
  - SIMULATION FACILITIES

National Research Council Canada / Conseil national de recherches Canada

Space Station Briefing
NASA HQ.
13 - 15 Sept. '82
Sheet 6

COST/BENEFIT ANALYSIS

- ESTABLISH COST/BENEFIT ANALYSES FOR VARIOUS LEVELS OF PARTICIPATION AND SPACE STATION USAGE

ALTERNATIVE ASSESSMENT

- EVALUATE ALTERNATIVES TO USE OF NASA SPACE STATION
  - O FREE FLYERS
  - O ESA SPACE STATION

PARALLEL STUDIES MONITORING

- ENSURE THAT STUDIES ARE IN SYNC WITH STUDIES BY NASA AND ESA

CANADIAN GOVERNMENT ROLE

- NATIONAL RESEARCH COUNCIL OF CANADA (NRCC) HAS BEEN IDENTIFIED AS THE LEAD AGENCY FOR THE STUDY PHASE
- INDUSTRY STUDY WILL PROVIDE A MAJOR INPUT TO INTERDEPARTMENTAL COMMITTEE ON SPACE (ICS) ON ROLE OF CANADA IN SPACE STATION PROGRAM
- OTHER INTERNAL GOVERNMENT STUDIES WILL BE USED TO COMPLEMENT THE INDUSTRY STUDY
- RECOMMENDATION OF APPROPRIATE LEVEL OF INTERNATIONAL PARTICIPATION WILL BE MADE TO ICS IN JULY 1983

III. c) JAPANESE SPACE STATION STUDY

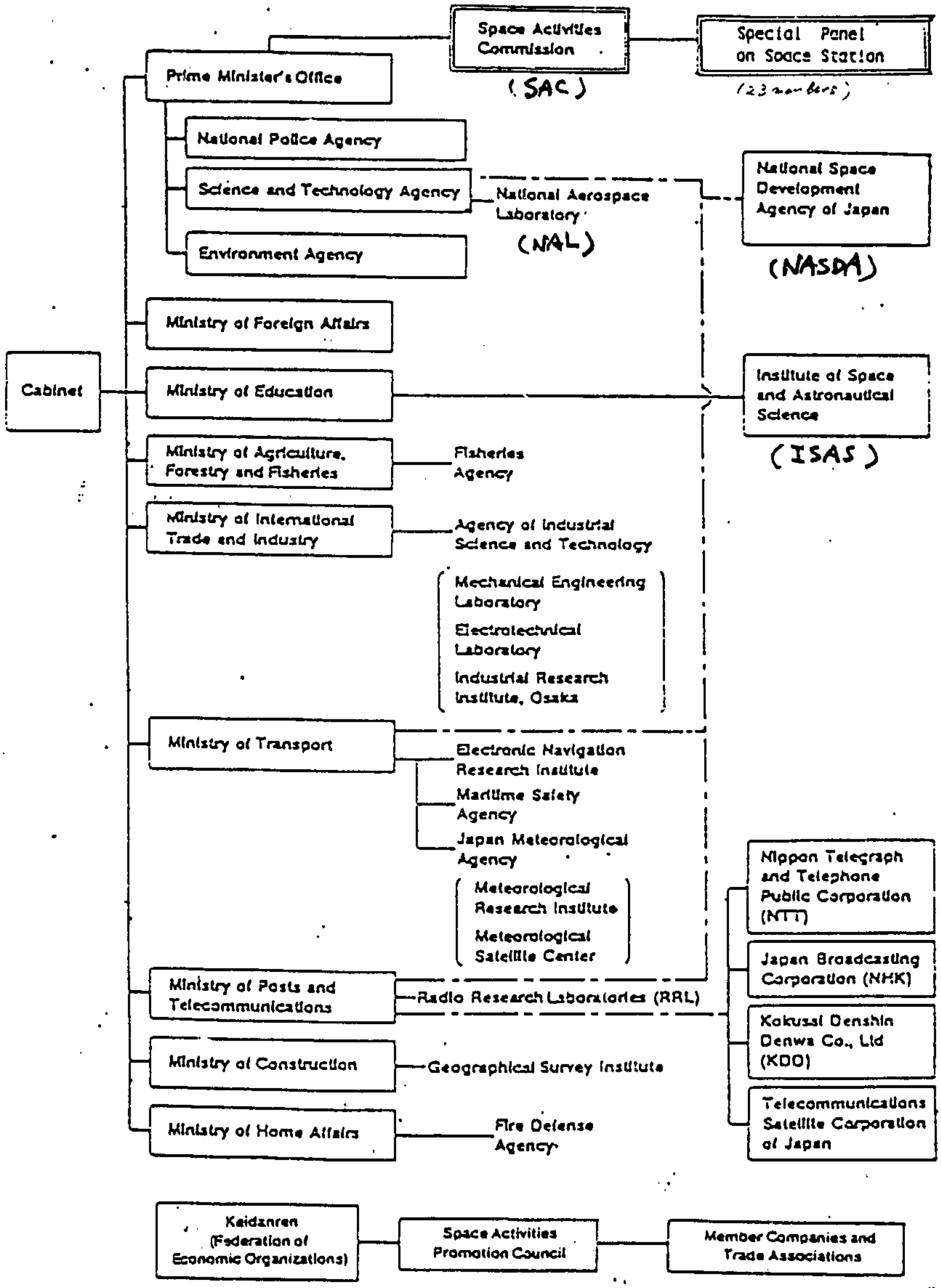
MASATOSHI SAITO

NASDA

JAPAN

(6)

Principal Organizations Related to Space Development in Japan

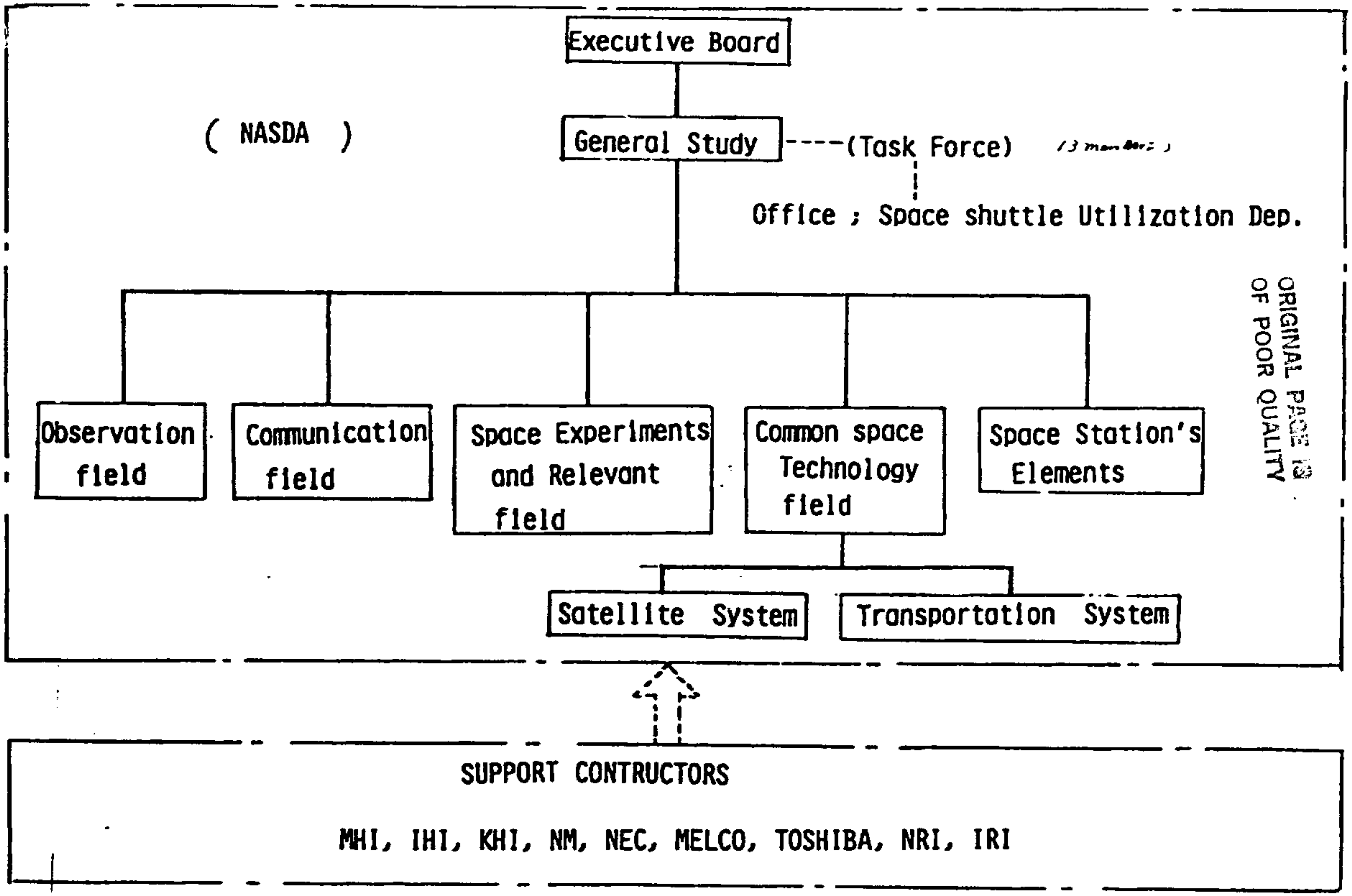


MILESTONES

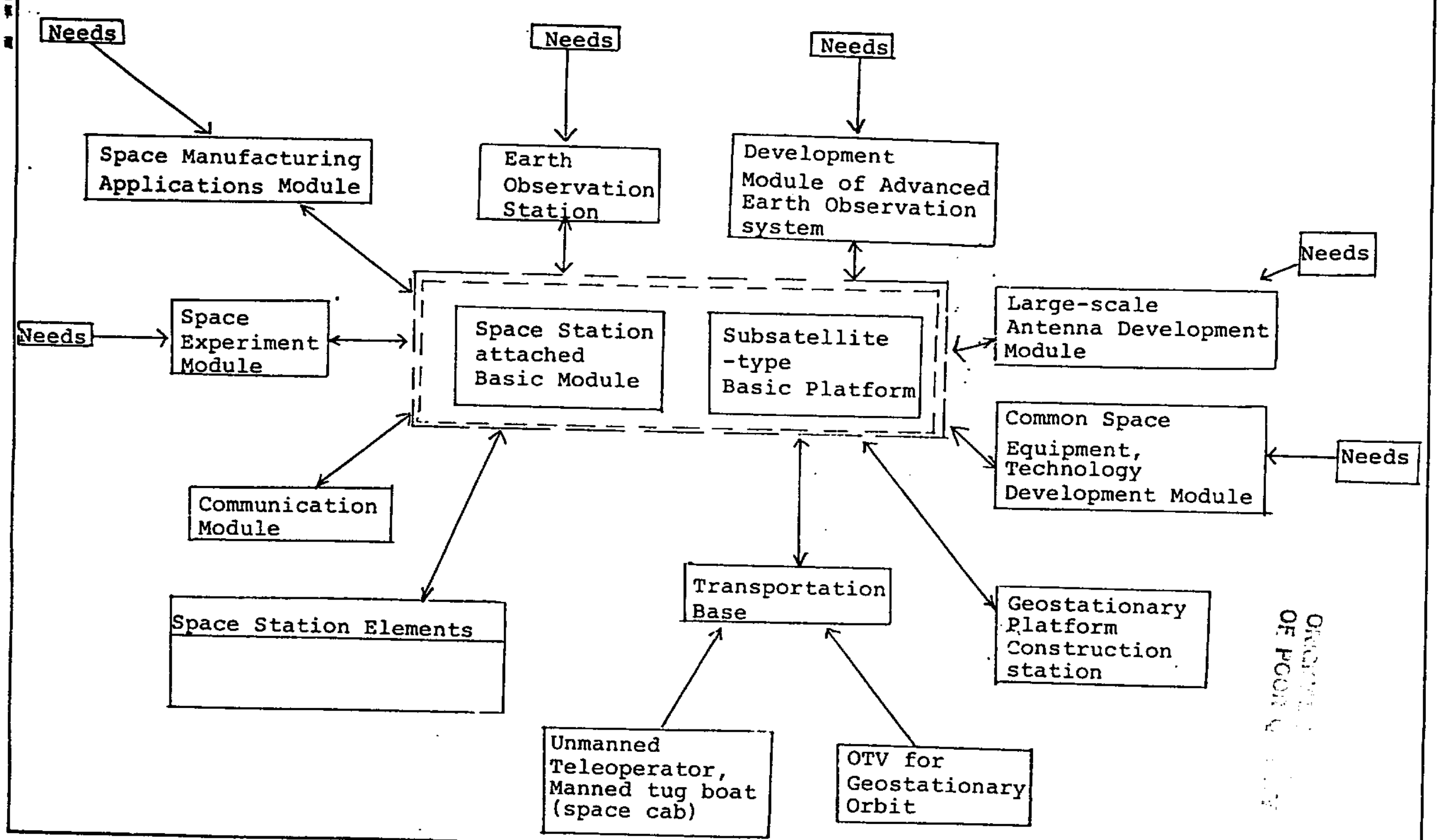
SEPT 1982

AUGUST 31, 1982	SPECIAL PANEL FOR SPACE STATION WAS ORGANIZED UNDER SPACE ACTIVITIES COMISSION TO ASSESS NATIONAL PLAN
SEPTEMBER 9, 1982	1ST MEETING OF SPECIAL PANEL FOR SPACE STATION
OCTOBER 21, 1982	SPACE STATION SYMPOSIUM
NOVEMBER 1982	STATUS OF JAPANESE STUDY IS PRESENTED AT STANDING SENIOR LIAISON GROUP MEETING AT NASA HQ
MAY 1983	INTERIM REPORT ON BASIC CONCEPT OF NATIONAL PLAN WILL BE SUBMITTED TO SAC BY SPSS

Supervision of NASDA Study



NASDA Study Flow



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NASDA

SUPPORT CONTRUCTORS (TENTATIVE)

	Observation field	Communication field	Space Experiments and Relevant field	Common space Technology field: Satellite System	Common space Technology field: Transportation System	Space Station's Elements
MHI			○	○	○	○
IHI			○		○	○
KHI			○			○
NM					○	○
NEC	○	○		○		○
MELCO		○		○	○	○
TOSHIBA	○	○		○		○
NRI			○			
IRI			○			

PROPOSAL FOR SPACE STATION MISSION

SEPTEMBER 1982

INSTITUTE OF SPACE AND ASTRONAUTICAL SCIENCE

1. INFRARED INTERFEROMETER IN SPACE (IRIS)
   INFRARED OBSERVATORY IN SPACE (IROS)
2. X-RAY OBSERVATORY
3. COMPOSITION AND NUCLEAR INTERACTION OF HEAVY PRIMARIES IN COSMIC RAYS
   ISOTOPE SEPARATION OF HIGH ENERGY HEAVY PRIMARIES
4. LINE GAMMA RAYS
   GAMMA RAY BURST DETECTION
5. GRAVITY WAVE DETECTION IN SPACE
6. TETHER EXPERIMENT
7. ADVANCED SEPAC
8. OBJECTIVES OF METRAS/MINIX
9. COLLISION PROTECTION RADAR EXPERIMENT (COPREX)
   TYPICAL RADAR PERFORMANCE
10. SPACE AGRICULTURE EXPERIMENT
11. MOLECULAR BEAM GRAPHOEPITAXY (MBGE)
12. TRIAL PROCESS OF AMORPHOUS SI CELL FOR SPS
13. MPD SOLAR ELECTRIC PROPULSION TEST
14. DEPLOYABLE SOLAR ARRAY MODULE

SPACE STATION STUDY IN NAL

STUDIES ON SPACE AGRICULTURE AND ECOLOGICAL LIFE SUPPORT SYSTEM

MICROGRAVITY_RELEVANT MATERIALS SCIENCE AND TECHNOLOGY OF JAPAN

MULTIPURPOSE SOLAR COLLECTOR

REAL TIME REPORTING SYSTEM ON OCEAN CONDITIONS

VIBRATION-FREE BENCH FOR MICROGRAVITY EXPERIMENTS

SPACE TEST FACILITY FOR ELECTRIC PROPULSION

LINEAR ACCELERATION AS A NEW ORBIT TRANSFER VEHICLE (OTV)

NATIONAL AEROSPACE LABORATORY
1880 JINDAIJI, CHOFU, TOKYO, JAPAN

III. d) GERMAN SPACE PROGRAM ACTIVITIES

DR. GOTTFRIED GREGER

BMFT

GERMANY

BMFT - 512 - 1

13.09.1982

MAIN TOPICS OF THE 4th GERMAN SPACE PROGRAM 1982 - 1986:

- DEVELOPMENT AND/OR OPERATION OF ORBITAL SYSTEMS:
  SPACELAB, SPACE PLATFORMS, ELEMENTS OF STATIONS
- UTILIZATION OF THESE TECHNOLOGIES FOR MICROGRAVITY RESEARCH AND APPLICATIONS
  REMOTE SENSING, COMMUNICATION AND EXTRATERRESTRIAL RESEARCH

PROJECTS ARE REALIZED OR UNDER PREPARATION

- IN THE NATIONAL PROGRAM,e.g. TEXUS, MAUS, SPAS, MISSION D1, ROSAT, PROPULSION MODULES AND POWER SYSTEMS FOR SPACE PLATFORMS
- IN EUROPEAN COOPERATION e.g.
  SPACELAB, EURECA, STS-LONGTERM PREPARATORY PROGRAM

BMFT - 512 - 2 13.09.1982

FOR SPACE TRANSPORTATION AND ORBITAL SYSTEMS ACTIVITIES

FRG (LIKE FRANCE FOR THE DEVELOPMENT OF ARIANE LAUNCHERS) PUTS SPECIAL EMPHASIS ON LEADERSHIP FOR THE DEVELOPMENT AND UTILIZATION OF ORBITAL SYSTEMS BASED ON REUSABLE SYSTEMS IN CLOSE EUROPEAN AND TRANSATLANTIC COOPERATION

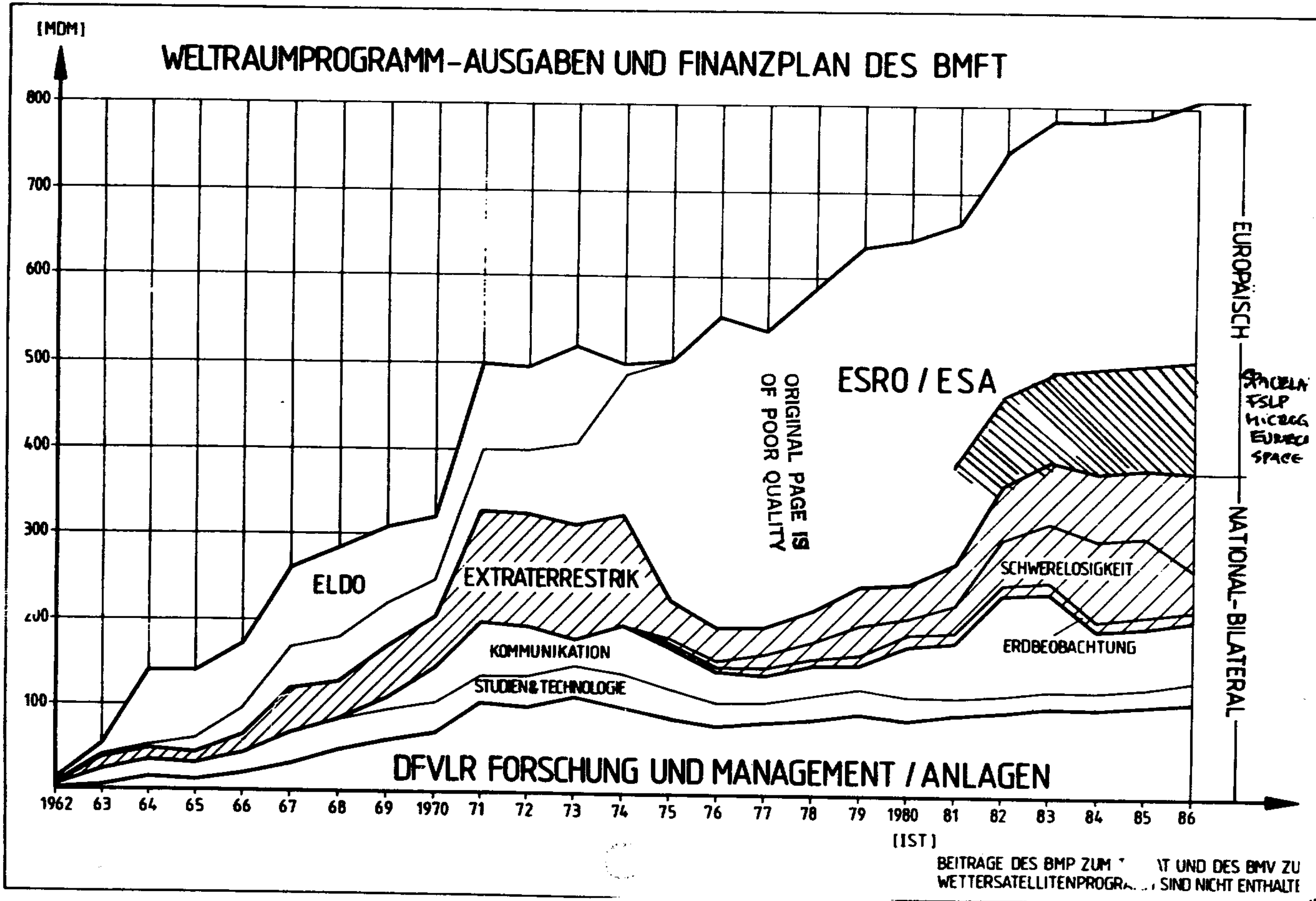
GERMAN FINANCIAL ENGAGEMENT IS SUBSTANTIAL:

ABOUT 100 Mio DM PER YEAR ARE SPENT

- WITHIN THE NATIONAL PROGRAM FOR RELATED PROJECTS AS WELL AS
- WITHIN THE ESA-PROGRAM; FRG IS PARTICIPATING IN SPACELAB-DEVELOPMENT (64,78 %), FSLP (56,27 %), EURECA (44,00 %), MICROGRAVITY PROGRAM (27,57 %), STS-LONGTERM-PROGRAM PREPARATION (UNDER DISCUSSION)

09.09.1982

BMFT-512-3



BEITRAGE DES BMP ZUM … IT UND DES BMV ZU WETTERSATELLITENPROGR… SIND NICHT ENTHALTE

BMFT - 512 - 4

13.09.1982

STS LONGTERM PROGRAM PREPARATION

WITHIN THE GERMAN NATIONAL PROGRAM BASIC SYSTEM STUDIES, TECHNICAL DEFINITION STUDY WORK AND EARLY PROJECTS ARE UNDER WAY

- TO COVER SPECIAL NEEDS WITHIN THE CURRENT GERMAN NATIONAL SPACE PROGRAM
- TO PROVIDE NECESSARY DECISION ELEMENTS FOR
  - o THE FUTURE ORIENTATION OF THE GERMAN SPACE PROGRAM
  - o THE EVALUATION OF THE POTENTIAL OF INTERNATIONAL, ESPECIALLY TRANSATLANTIC COOPERATION
  - o THE ASSESSMENT OF AN APPROPRIATE GERMAN PARTICIPATION IN FUTURE ESA PROGRAMS

BMFT - 512 - 5

13.09.1982

STS-LONGTERM PROGRAM PREPARATION

PRESENT ACTIVITIES ARE BASED ON

- COMPREHENSIVE CONCEPT STUDY ON SHUTTLE BASED RETRIEVABLE SPACE PLATFORMS (MBB/ERNO)
  - -- IN LEO FOR MICROGRAVITY RESEARCH AND APPLICATIONS
    FOR EARTH OBSERVATION
    FOR SPACE SCIENCE (X-RAY, IR-TELESCOPES)
  - -- IN GEO FOR COMMUNICATION AND NAVIGATION SYSTEMS

  RESULTING IN THE GERMAN INITIATIVE FOR THE ESA-EURECA-PROGRAM

- OPERATION OF A FIRST RETRIEVABLE PAYLOAD CARRIER SPAS 01 FIRST FLIGHT MID 1983 (MBB-INITIATIVE, JOINT MBB/BMFT VENTURE)
- PREPARATION OF AN X-RAY-SATELLITE (PLATFORM) ROSAT, BILATERAL PROJECT WITH NASA AND UK

BMFT - 512 - 6

13.09.1982

STS-LONGTERM PROGRAM PREPARATION

OBJECTIVES FOR PRESENT GERMAN ACTIVITIES:

- INVESTIGATE SPECIFIC UTILIZATION, TECHNICAL AND PROGRAMMATIC ASPECTS TO DEFINE THE GERMAN POLICY AND DECISIONS
- COMPLEMENT ESA-ACTIVITIES, AS FAR AS GAPS ARE EXISTING OR ADDITIONAL FEATURES ARE OF INTEREST
- DEFINE ELEMENTS FOR FUTURE ORBITAL SYSTEMS WHICH ARE OF SPECIFIC GERMAN INTEREST AND IMPORTANCE AND PREPARE THEIR IMPLEMENTATION

BMFT - 512 - 7

13.09.1982

STS LONGTERM PROGRAM PREPARATION

1. ANALYSIS OF DEMAND FOR FUTURE ORBITAL SYSTEMS, THEIR ARCHITECTURE AND ALTERNATIVES FOR IMPLEMENTATION

- UTILIZATION ASPECTS AND REQUIREMENTS FOR FUTURE SPACE TRANSPORTATION AND ORBITAL SYSTEMS (SL, AUTOMATED IN ORBIT INFRASTRUCTURE (IoI), SPACE STATION, COMBINED SYSTEMS)
- MANNED ASPECTS OF FUTURE EUROPEAN ORBITAL SYSTEMS RELATED TO US-SPACE STATION CONCEPTS
- IDENTIFICATION OF COMMON ELEMENTS OF EUROPEAN ORBITAL SYSTEMS AND US-SPACE STATION TO MAXIMIZE ECONOMY
- DEVELOPMENT OF LONGTERM GERMAN PROGRAM CONCEPTS COMBINING THE EVOLUTION OF SPACE UTILIZATION AND THE DEVELOPMENT AND STEPWISE INSTALLATION OF ADVANCED ORBITAL SYSTEMS

STUDY TEAM: DFVLR/MBB-ERNO/DS

DURATION: 9 MONTHS

COST ESTIMATE: 1,0 Mio DM

BMFT - 512 - 8 13.09.1982

STS LONGTERM PROGRAM PREPARATION

2. PREPARATION OF ORBITAL SYSTEMS ELEMENTS:

2.1 PHASE A-STUDY OF AN INTER-ORBIT TRANSFER AND LOGISTICS VEHICLE (IOTLV)

IOTLV IS A MAJOR ITEM REQUIRED FOR FUTURE ORBITAL OPERATIONS AND SUPPLY OF SPACE PLATFORMS OR SPACE STATIONS

IT IS TO BE BASED ON THE GALILEO RETRO PEOPULSION MODULE (RPM) CURRENTLY UNDER DEVELOPMENT BY MBB FOR NASA/JPL

BMFT - 512 - 9

13.09.1982

POSSIBLE TASKS FOR IOTLV:

TRANSFER OF PAYLOADS FROM SHUTTLE STANDARD ORBIT
(300 km/28,5°) to higher orbits and return

SUPPLY AND MODULE EXCHANGE/TRANSFER FOR SPACE PLATFORMS OR SPACE STATIONS

SPACE PLATFORM ORBIT CORRECTIONS (RESTITUTION)

TECHNOLOGY AND ORBIT OPERATIONS TEST VEHICLE
(ORBITAL ASSEMBLY, RdV AND DOCKING, PROPELLANT TRANSFER, ROBOTICS)

MANOEUVRING OF RE-ENTRY MODULES, OR CONTROLLED RE-ENTRY OF FAILED SPACECRAFT (DE-ORBITING)

INSPECTION OF FAILED OR DAMAGED SPACECRAFT; DEBRIS COLLECTION, SPACECRAFT RECOVERY

BMFT - 512 - 10

13.09.1982

STS LONGTERM PROGRAM PREPARATION

2. PREPARATION OF ORBITAL SYSTEMS ELEMENTS:

2.2 PHASE A-STUDY OF A MODULAR SOLAR-ARRAY POWER SYSTEM (MOSA-PS)

DEVELOPMENT OF A VERSATILE AND COST EFFECTIVE POWER SYSTEM TO BE APPLIED FOR EUROPEAN SPACE PLATFORMS AS WELL AS STS ENHANCEMENT AND SPACE STATIONS DELIVERING BY MODULAR COMBINATION OF STANDARD SOLAR CELLS/BLANKETS

ELECTRICAL POWER OUTPUT RANGING FROM 3 TO 30 KW

GALILEO RETRO PROPULSION MODULE

MBB

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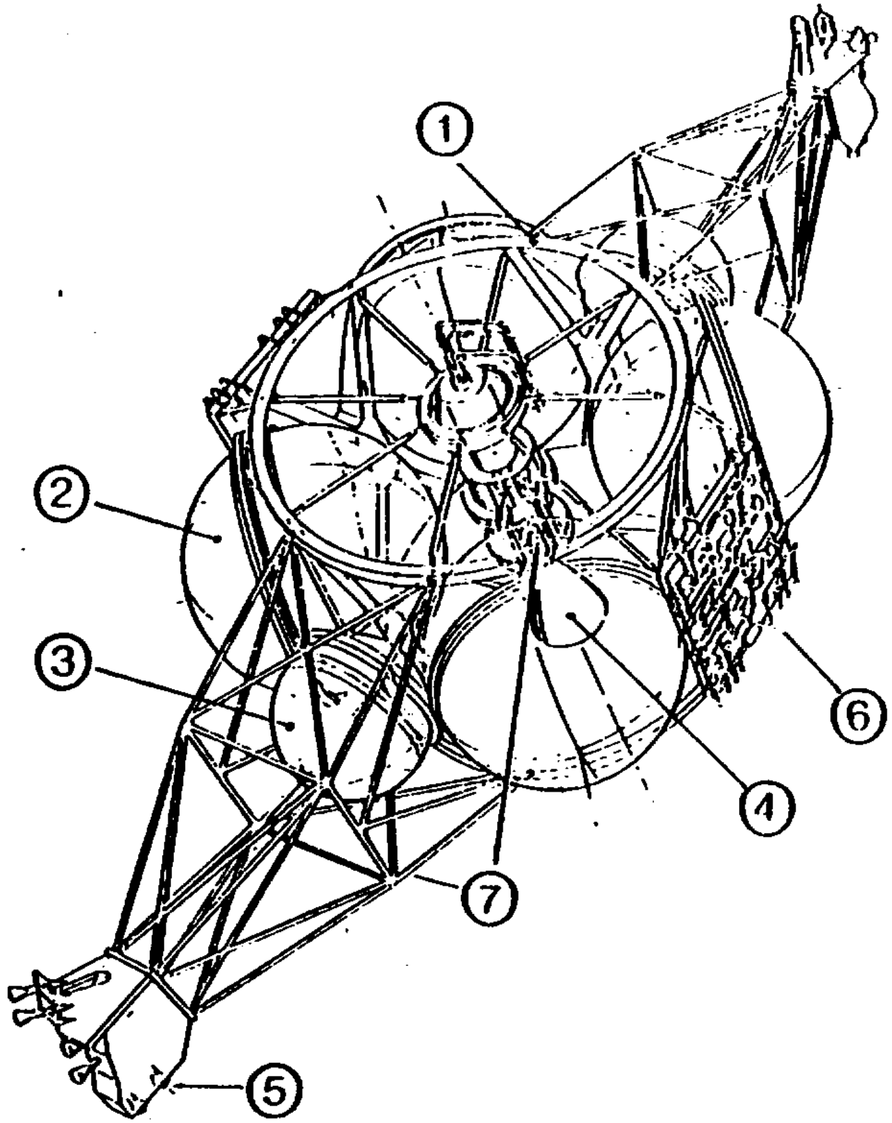

RPM ELEMENTS

(1) STRUCTURE

(2) PROPELLANT TANKS (4)

(3) PRESSURANT TANKS (2)

(4) 400 N ENGINE ASSEMBLY (1)

(5) 10 N THRUSTERS (12), 2 CLUSTERS

(6) PRESSURIZATION & FEED SYSTEM

- PCA/PIA ON 2 EQUIPMENT PANELS
- TUBING

(7) THERMAL CONTROL (BLANKETS, ELECTRICAL HEATERS) FOR

- THRUSTER CLUSTERS, OUTRIGGERS
- 400 N ENGINE

(8) ELECTRICAL CABLING

MBB

The MBB - Concept

- A modular, multipurpose vehicle consisting of mission-dedicated modules
  - The BASIC ORBITAL PROPULSION MODULE (MOPS) with 2 to 4 tons propellant
  - An EQUIPMENT MODULE for independent flight operations
  - A MANIPULATOR MODULE for orbital servicing and inspection
  - A TANK MODULE for doubling the performance (delta V or payload)
- Designed for Shuttle Orbiter retrieval (and launch) but also applicable for ARIANE launch.

MBB

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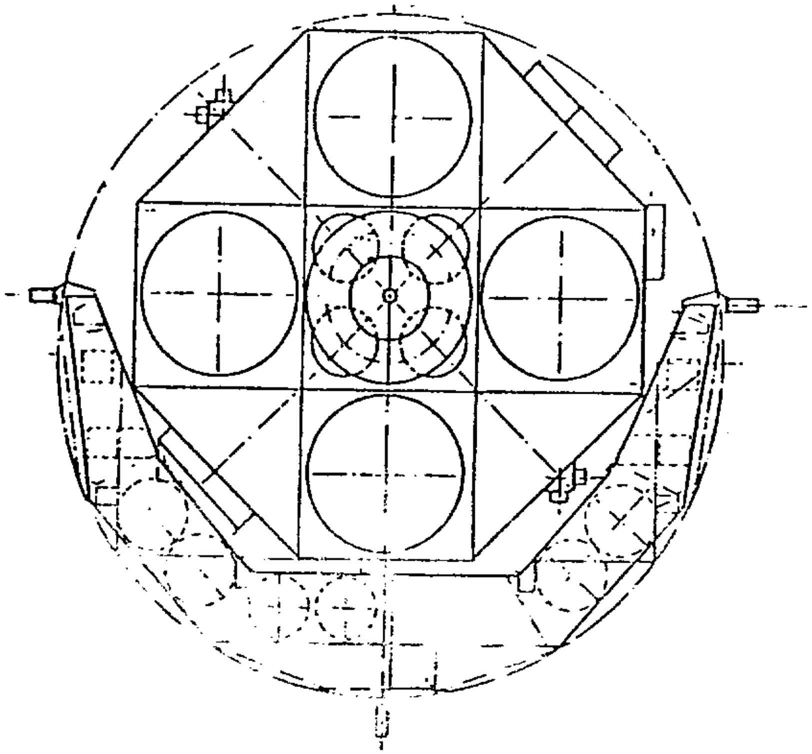
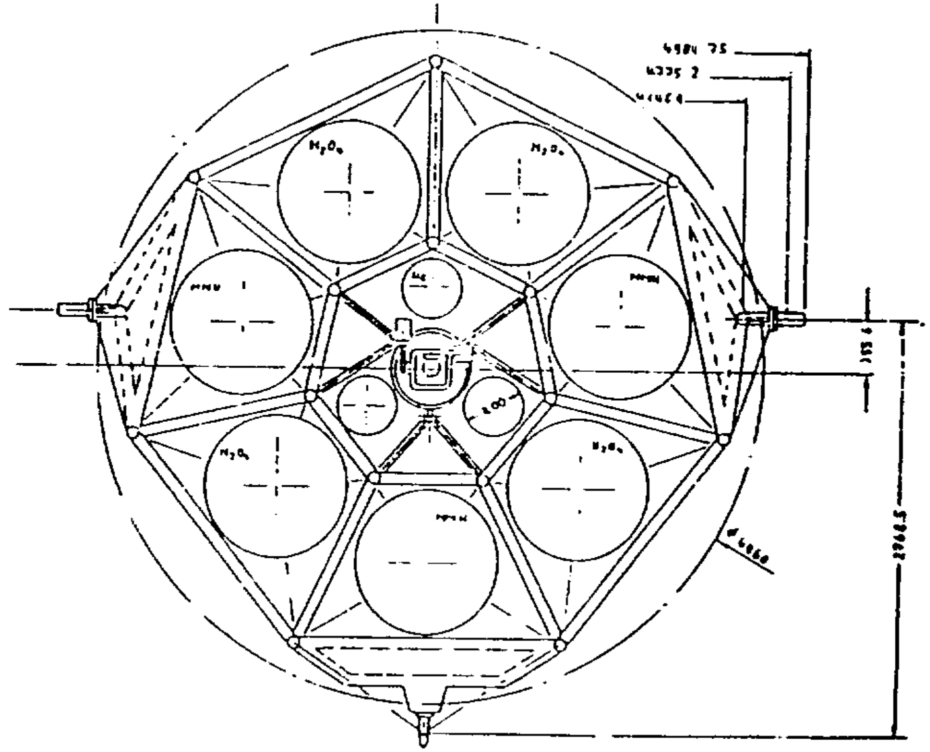


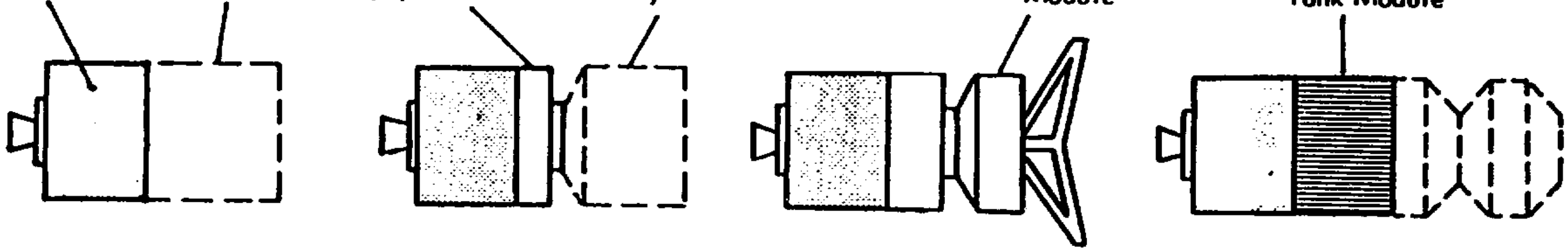
[illegible] ARIANE 4 ([illegible]6 m diameter) and Recovery by the SHUTTLE ORBITER



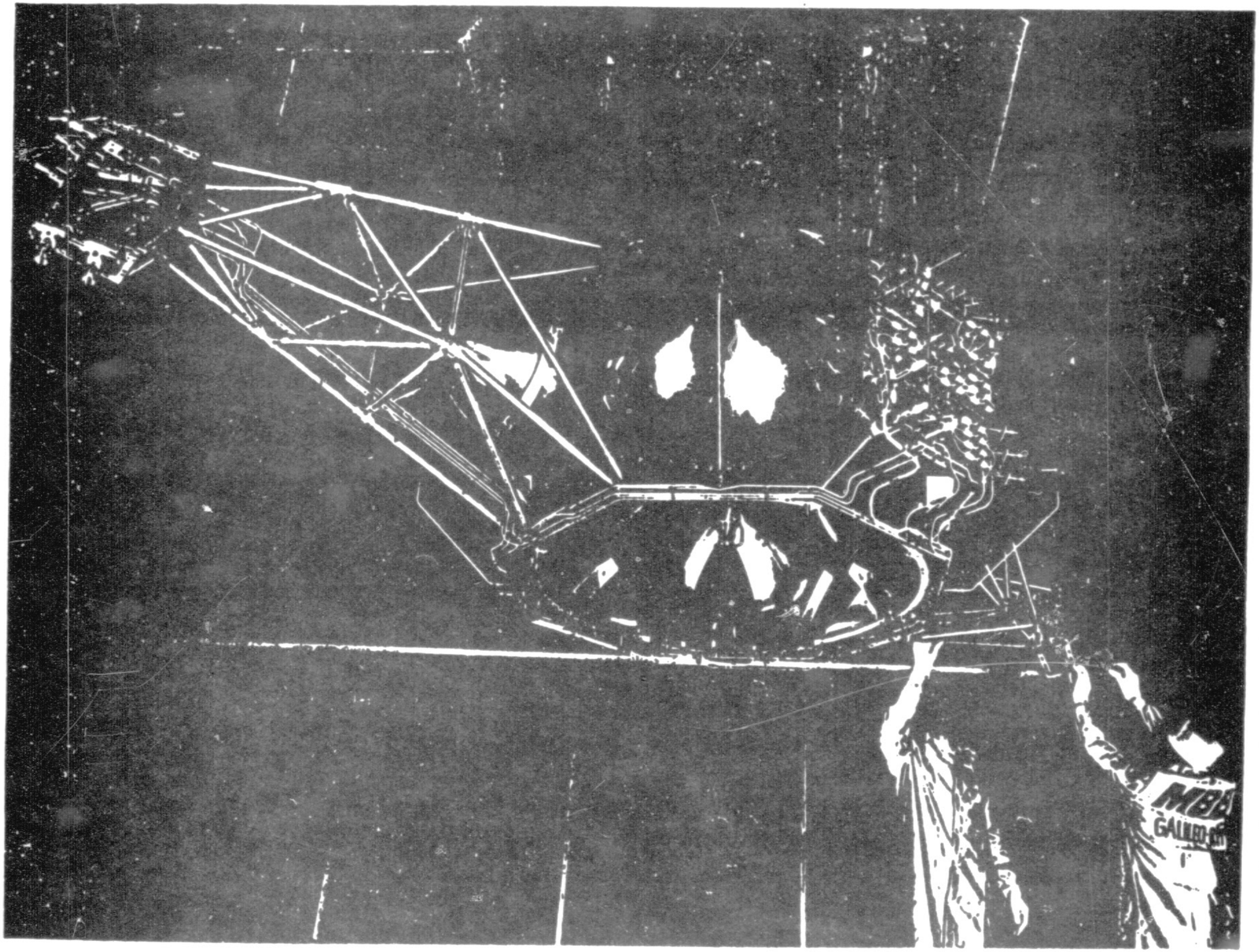
Vehicle Concept for SHUTTLE ORBITER Launch and Recovery
(4.5 m diameter)

MODULAR ASSEMBLIES

for a wide range of orbital operations



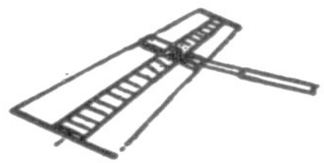
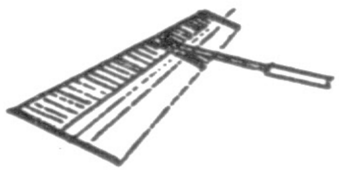
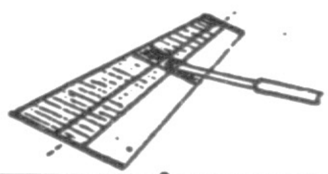
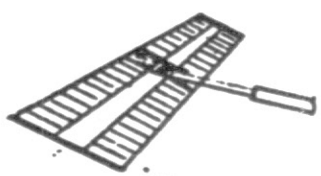
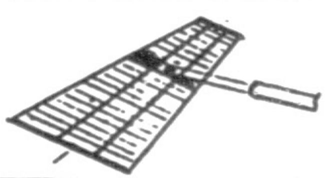
MOPS as attached module for ARIANE- and SHUTTLE-payloads (expendable)	MOPS with Equipment Module as Reusable Perigee Stage (Shuttle) (reusable)	MOPS with Equipment Module and Manipulator Module for Satellite Servicing (reusable)	MOPS with Tank Module for Increased Performance (expendable or reusable)



RPM
Qualification
Unit, delivered
to JPL

ADAPTATION OF MODULAR ARRAY ON PLATFORM NEEDS

SINGLE ARRAY

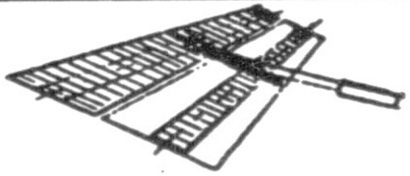
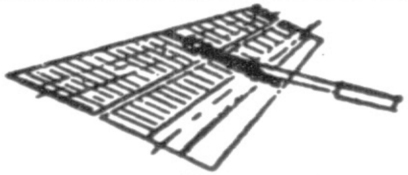
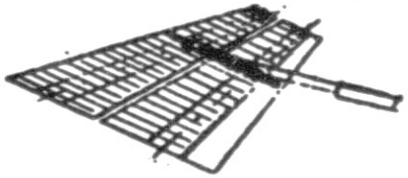
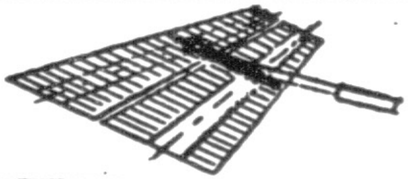
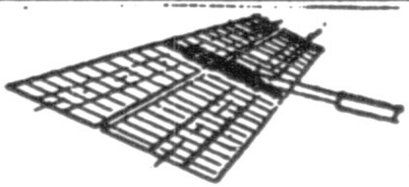
	EL. POWER B.O.L	PLATFORM / PAYLOAD		STUDIED BY
	3 KW	FRC 3 (0.6KW)	X-RAY ASTRON.	ESA/ERNO
	6 KW	RMP (6KW)	MICROGRAVITY	ESA/ERNO
	9 KW	FRC 4 (7KW) FRC 11 (8KW)	CLIMATOL./METEOR. REMOTE SENSING	ESA/ERNO ESA/ERNO
	12 KW			
	15 KW			

ERNO
RAUMFAHRTTECHNIK GMBH

MOSA-Power System

ADAPTATION OF MODULAR ARRAY ON PLATFORM NEEDS (CONT'D)

DOUBLE ARRAY

	EL.POWER B.O.L	PLATFORM / PAYLOAD	STUDIED BY
	18 KW	EUROS – SERVICE MODULE (18,5KW B.O.L ≙ 10KW E.O.L-CONT) MULTI-DISCIPLINARY PAYLOAD	ESA/ERNO
	21 KW	SOLARIS–ORBITAL SERVICE MODULE (20KW B.O.L ≙ 10KW E.O.L. CONTIN.) MULTI-DISCIPLINARY PAYLOAD	CNES
	24 KW	US–POWER SYSTEM (23KW B.O.L ≙ 12,5KW E.O.L CONTIN.)	MSFC/TRW
	27 KW		
	30 KW	PEP – ORBITER ELECTR. POWER AUGMENT. (32,88KW B.O.L) RPS – LIKE PEP BUT 30KW B.O.L	JSC/MCDAC AEG/SPAR

MAJOR ELEMENTS OF THE MODULAR CONCEPT

SOLAR ARRAY

MECHANICAL

- LIGHTWEIGHT FLEXIBLE FOLDABLE BLANKET
- FULL RETRACTABILITY
- DIMENSIONS :
  APPROX. 21.5 m x 3.75 m (PER WING)
- BLANKET MASS :
  APPROX. 80 KG (PER WING)
  APPROX. 1 KG/m^2

ELECTRICAL

- MODULAR POWER OUTPUT 30 KW MAX.
  (2 ARRAYS = 4 WINGS)
- HIGH ARRAY OUTPUT VOLTAGE
  120 ... 200 V (ADJUSTABLE)
- SHUNT DIODES INCORPORATED IN ARRAY DESIGN TO PREVENT SHADOW/HOT SPOT PHENOMENA

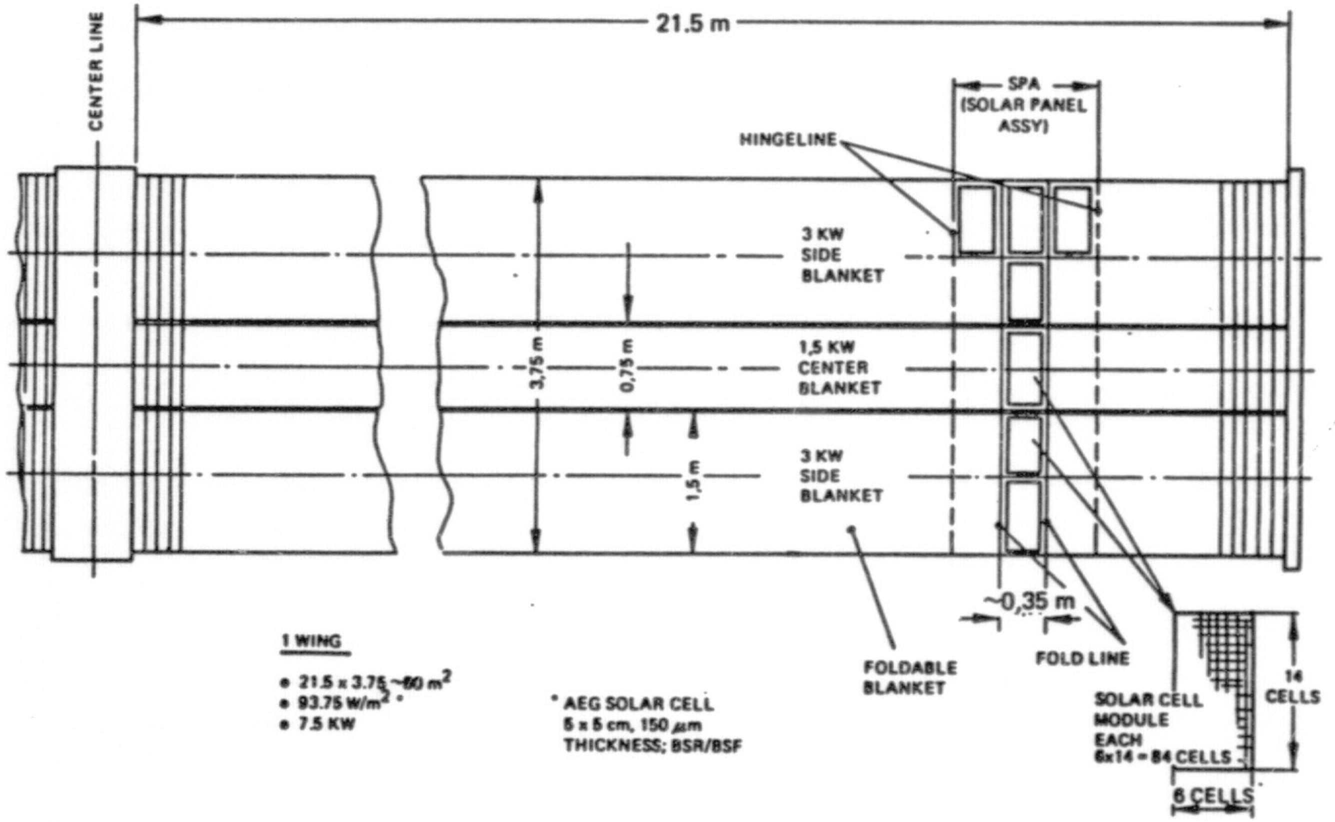
SOLAR CELLS

5 cm x 5 cm, 150 μm THICKNESS, BACK SIDE REFLECTOR (BSR), BACK SURFACE FIELD (BSF)

DEPLOYMENT MAST

(FULLY RETRACTABLE ASTROMAST)
SERVES TO DEPLOY THE TWO FOLDABLE BLANKETS IN OPPOSITE DIRECTION TO ACHIEVE A SYMMETRIC CONFIGURATION WITH THE GIMBAL ASSEMBLY IN THE CENTER (ONE ASTROMAST PER WING)

TYPICAL WING LAY-OUT



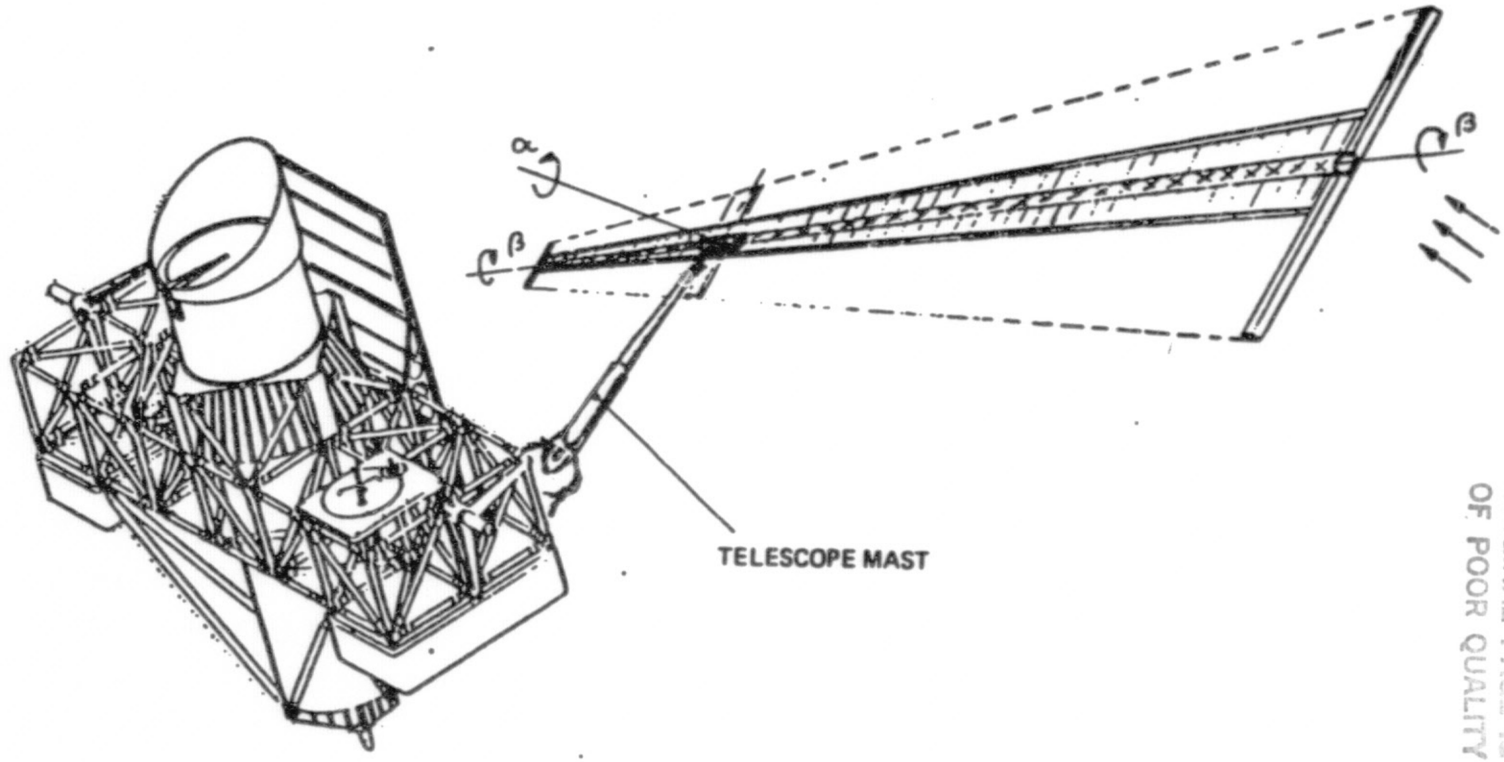
1 WING

- 21.5 x 3.75 ~80 m²
- 93.75 W/m² *
- 7.5 KW

* AEG SOLAR CELL
5 x 5 cm, 150 µm
THICKNESS; BSR/BSF

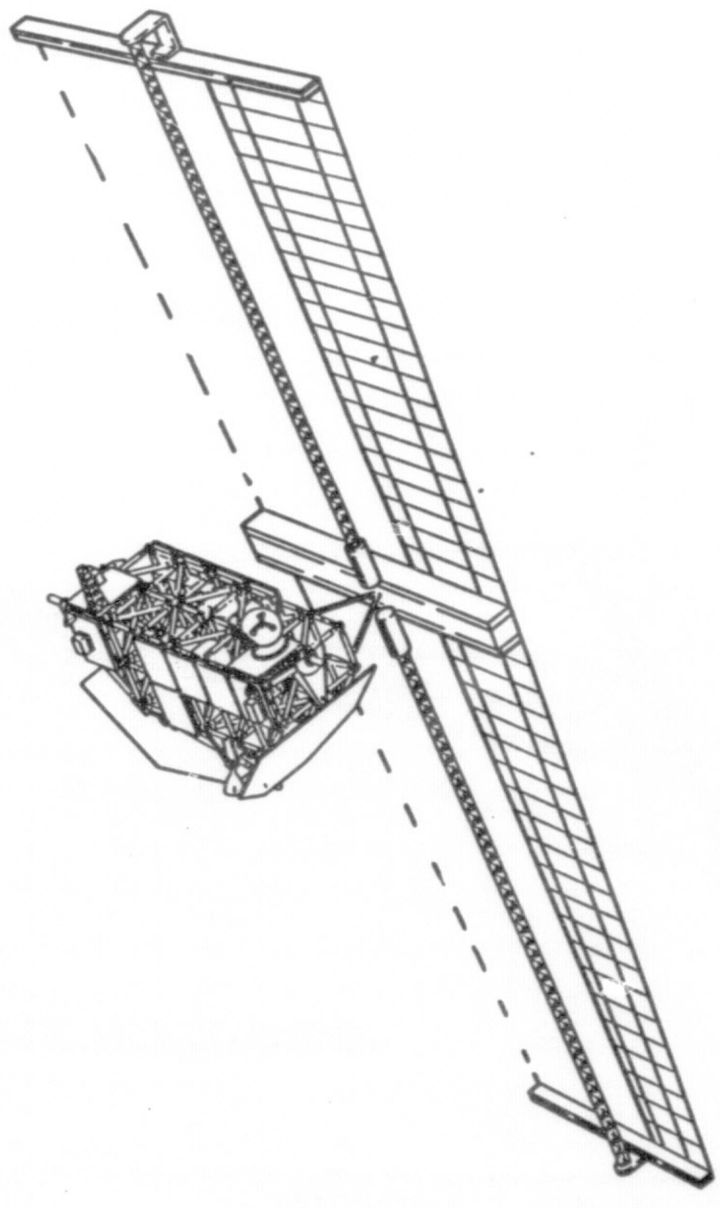
SIDE BLANKET DOUBLE SIZE OF CENTRE BLANKET FOR COMMON SOLAR CELL MODULES

SINGLE ARRAY (3 KW) ON SPAS (X-RAY ASTRONOMY PAYLOAD)

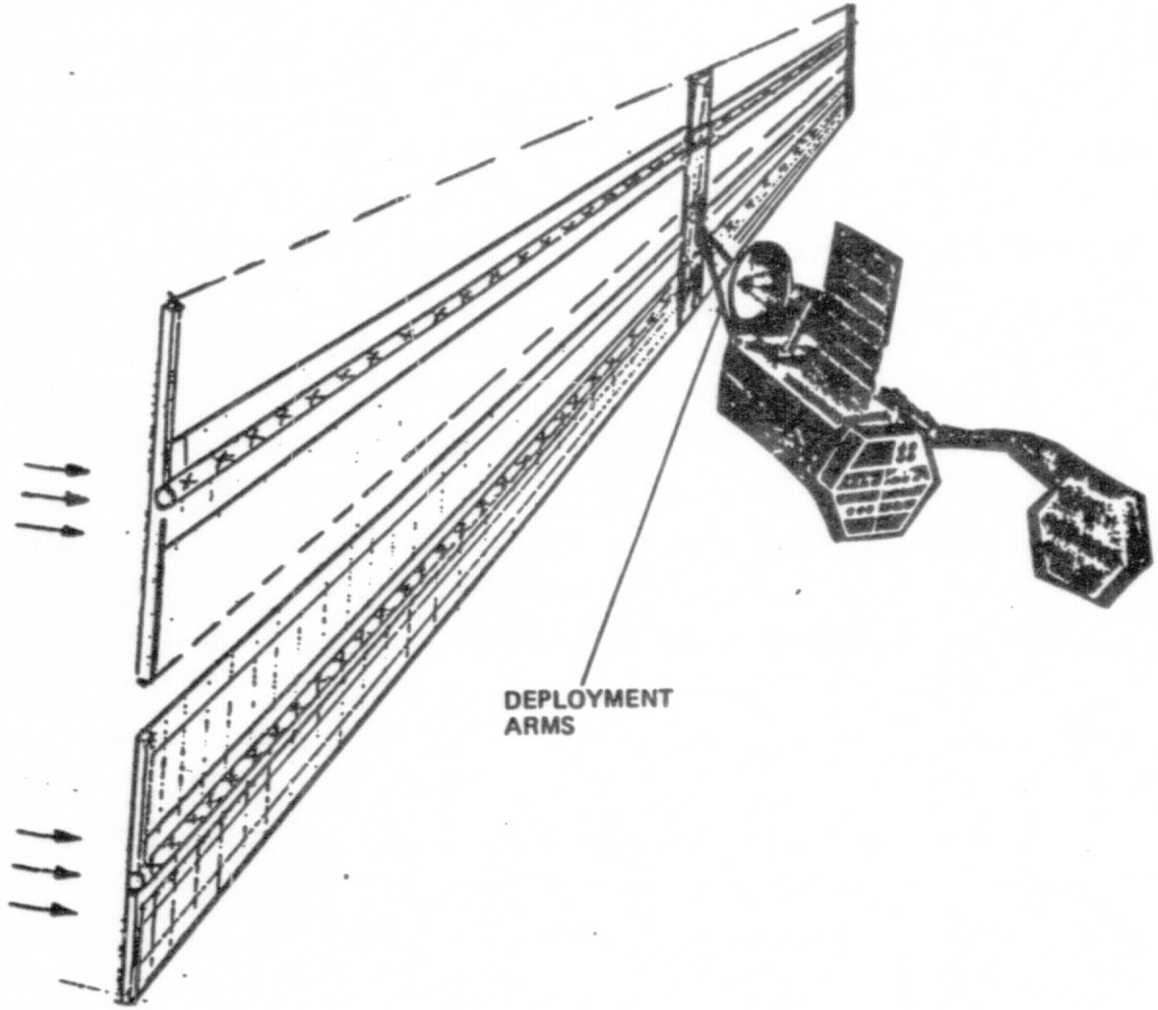


<u>SINGLE ARRAY (6 KW) ON SPAS–RMP</u>

(MICRO--GRAVITY PAYLOAD)



DOUBLE ARRAY (18 KW) ON EUROS – SERVICE MODULE



CNES ACTIVITIES ON FUTURE SYSTEMS

M. ALAIN PERARD

CNES

FRANCE

CNES ACTIVITIES ON FUTURE SYSTEMS

- <u>OBJECTIVE</u>

  -- TO PREPARE A DECISION ON FUTURE SYSTEMS FOR THE 90'S

- <u>APPROACH</u>

  A. PERFORM CONCEPT STUDIES BASED ON:

  -- DESIGN GOALS

  -- REFERENCE MISSIONS

  B. REFINE IN PARALLEL MISSION IDENTIFICATION AND ANALYSIS

  C. UPDATE SYSTEM STUDIES (BASED ON A & B)

  D. IDENTIFY AND ANALYSE ALTERNATIVES

3068B/1

THE SOLARIS SYSTEM

- **DESIGN GOALS**

  -- LAUNCH BY ARIANE 4/5

  -- LIFETIME: 15 YEARS

  -- RENDEZVOUS AND DOCKING CAPABILITY

  -- RETURN CAPABILITY

  -- GROWTH POTENTIAL

  -- PROVIDE TO PAYLOAD

    -- POWER: 10KW EOL

    -- DATA TRANSMISSION: 400 MB/S

    -- POINTING: 0.10 DEG

    -- ACCELERATION $< 10^{-5}$G

- **REFERENCE MISSIONS**

  -- MATERIAL PROCESSING

  -- EARTH OBSERVATION

  -- ORBITAL SERVICE (MAINTENANCE, SERVICING...)

  -- ASSEMBLY AND CONSTRUCTION

THE SOLARIS CONCEPT

- **SERVICE PLATFORM**

  -- AUTOMATIC PLATFORM ON SUN-SYNCHRONOUS ORBIT (BASELINE)

  -- PROVIDES BASIC RESOURCES TO PAYLOADS CARRIED AND EXCHANGED BY TRANSPORT VEHICLE

  -- MODULAR CONCEPT ALLOWING GROWTH POTENTIAL (INCLUDING SUPPORT OF MANNED MODULE)

- **TRANSPORT VEHICLE:** 2 CONCEPTS

  A. PARTIALLY RECOVERABLE--MANEUVERING AND REENTRY MODULES

  B. TOTALLY RECOVERABLE--WINGED VEHICLE

- **TELEMANIPULATOR:** TO BE INSTALLED ON SERVICE PLATFORM AND/OR ON TRANSPORT VEHICLE

- **RELAY SATELLITES**

3068B/3

CNES ACTIVITIES IN RELATION TO US SPACE STATIONS

- IDENTIFY POTENTIAL MISSIONS AND USERS

  EXTENSION OF WORK ALREADY UNDER PROGRESS TO INCLUDE US SPACE STATIONS:

  -- DESCRIPTION OF A "GENERIC" SPACE STATION

  -- QUESTIONNAIRE, CONTACTS WITH EXPERTS AND POTENTIAL USERS

  -- SORT MISSION REQUIREMENTS VS. POTENTIAL SOLUTIONS:

     "FREE FLYERS", AUTOMATIC PLATFORMS, MANNED STATIONS

  -- DERIVE INTEGRATED REQUIREMENTS

- INVESTIGATE POSSIBILITIES TO PARTICIPATE IN BUILDING SPACE STATIONS

  -- COMMONALITY OF ELEMENTS BETWEEN SOLARIS TYPE SYSTEMS AND SPACE STATIONS

  -- OTHER ELEMENTS

- ANALYSE IMPLICATIONS OF PARTICIPATING IN SPACE STATIONS (BUILDING AND UTILIZING)

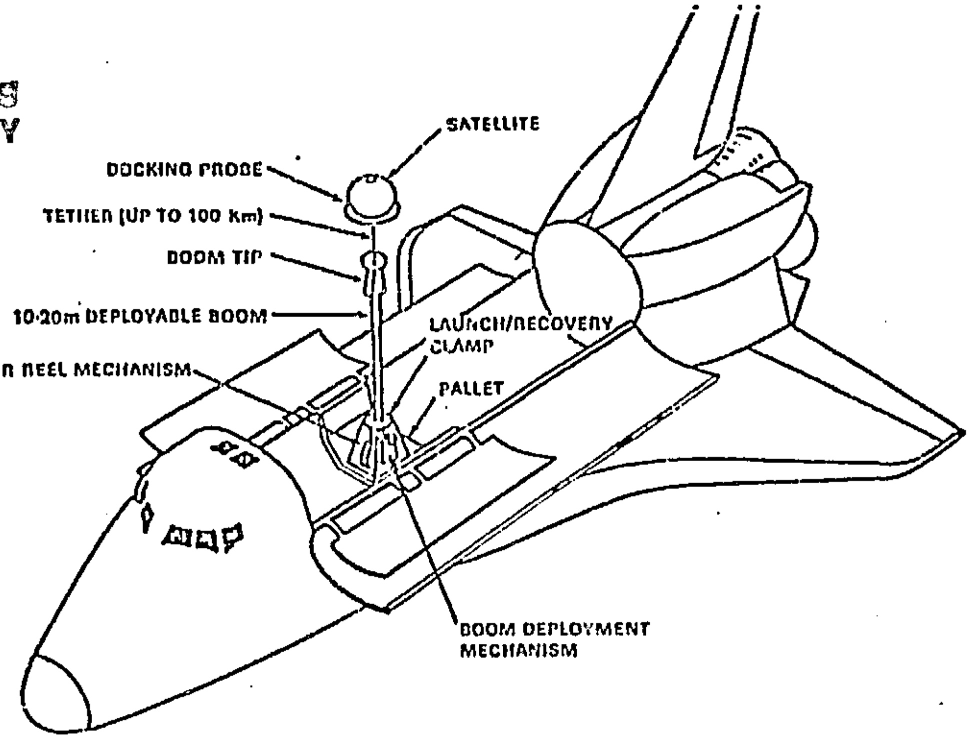
3068B/4

TETHERED SATELLITE PROGRAM

GIANFRANCO MANARINI

PSN/CNR

ITALY


SATELLITE
DOCKING PROBE
TETHER (UP TO 100 Km)
BOOM TIP
10-20m DEPLOYABLE BOOM
LAUNCH/RECOVERY CLAMP
TETHER REEL MECHANISM
PALLET
BOOM DEPLOYMENT MECHANISM

- Fig. 1 -

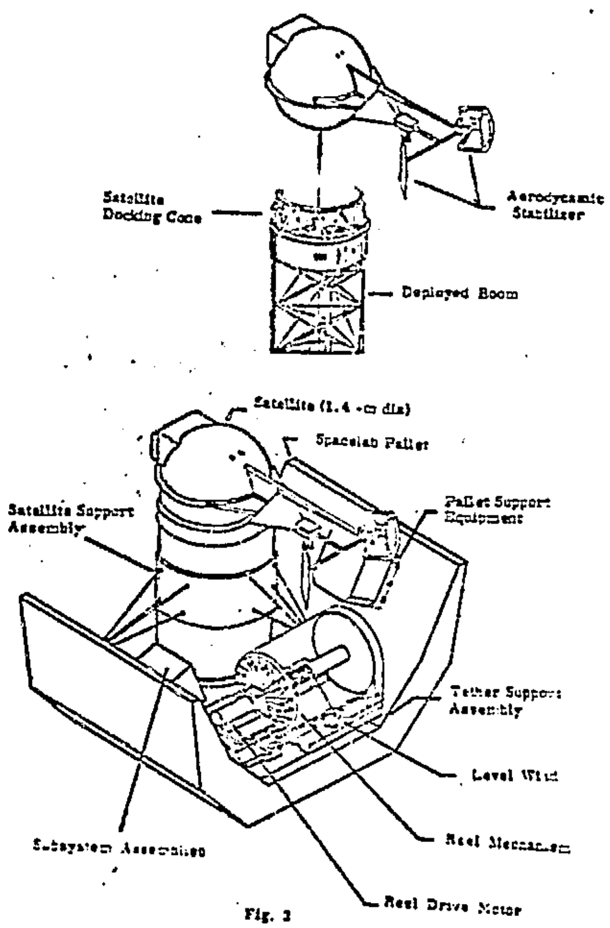

Satellite Docking Cone
Aerodynamic Stabilizer
Deployed Boom
Spacelab Pallet
Satellite Support Assembly
Pallet Support Equipment
Tether Support Assembly
Level Wind
Reel Mechanism
Subsystem Assemblies
Reel Drive Motor

Fig. 2

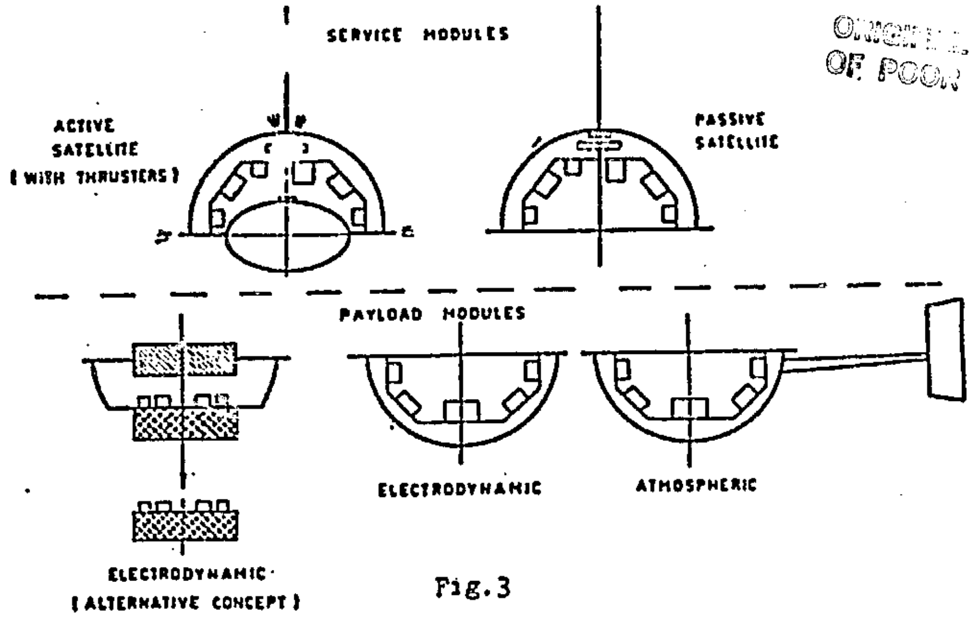
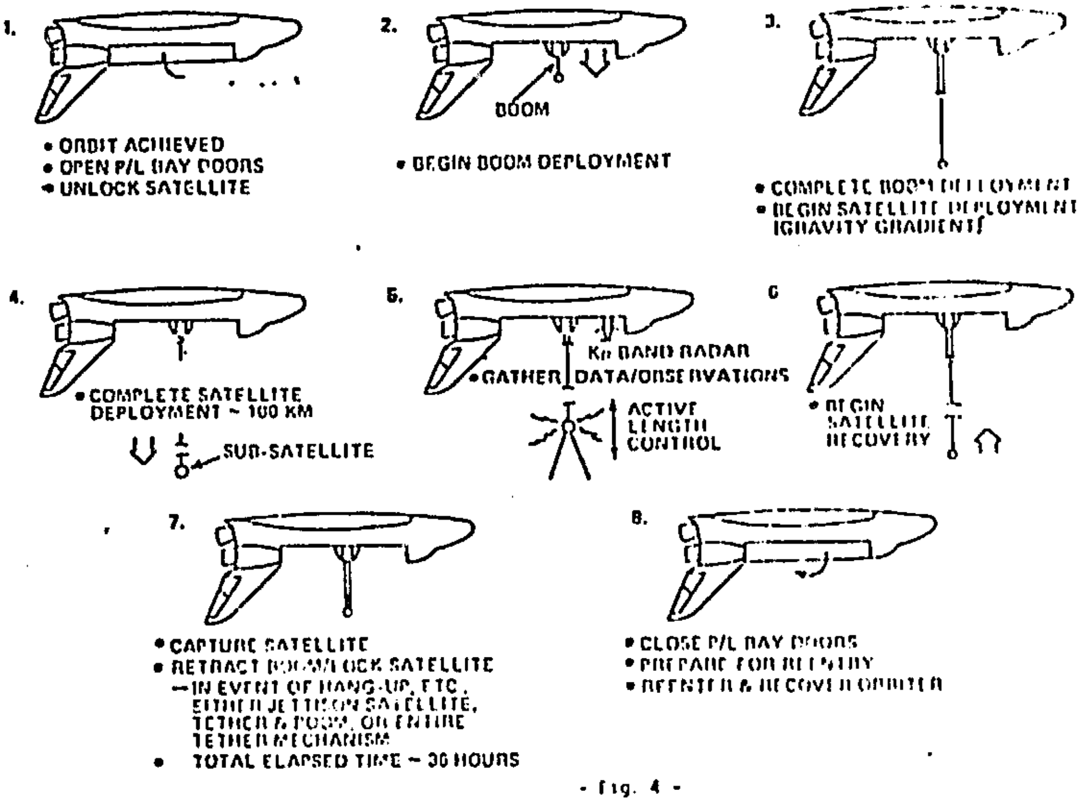


Fig.3

DEPLOYMENT/RETRIEVAL SEQUENCE



- Fig. 4 -

TSS CONCEPT FUTURE APPLICATIONS TO SPACE STATIONS

- SUBSYSTEM OF A SPACE STATION

  FACILITY FOR:
  - DEPLOYMENT AND RETRIEVAL OF PAYLOADS
  - PAYLOAD TRANSFER TO HIGHER OR LOWER ENERGY ORBITS
  - REENTRY
  - POWER GENERATION
  - ALFVEN ENGINE
  - VLF ANTENNA

- DOCKING FACILITY
  - A SHORT TETHER DEPLOYED BY THE STATION (THE VELOCITY OF THE TETHER END IS SLIGHTLY DIFFERENT FROM THE EQUILIBRIUM ORBITAL VELOCITY: 1 M/SEC WITH 1 KM TETHER AT 400 KM ALTITUDE).
  - A LONG TETHER DEPLOYED BY THE STATION (THE LENGTH OF THE TETHER IS CHOSEN IN ORDER TO PROVIDE A VELOCITY AT THE TETHER END EQUAL TO THE APOGEE VELOCITY OF THE SHUTTLE TRANSFER ORBIT).

- ARTIFICIAL LOW GRAVITY DEVICE

  A SUBSTATION DEPLOYED BY THE MOTHER STATION TO GENERATE A 0.1 G ACCELERATION (250 KM TETHER AT 400 KM ALTITUDE).

M-110

TETHER-ASSISTED ORBIT TRANSFER

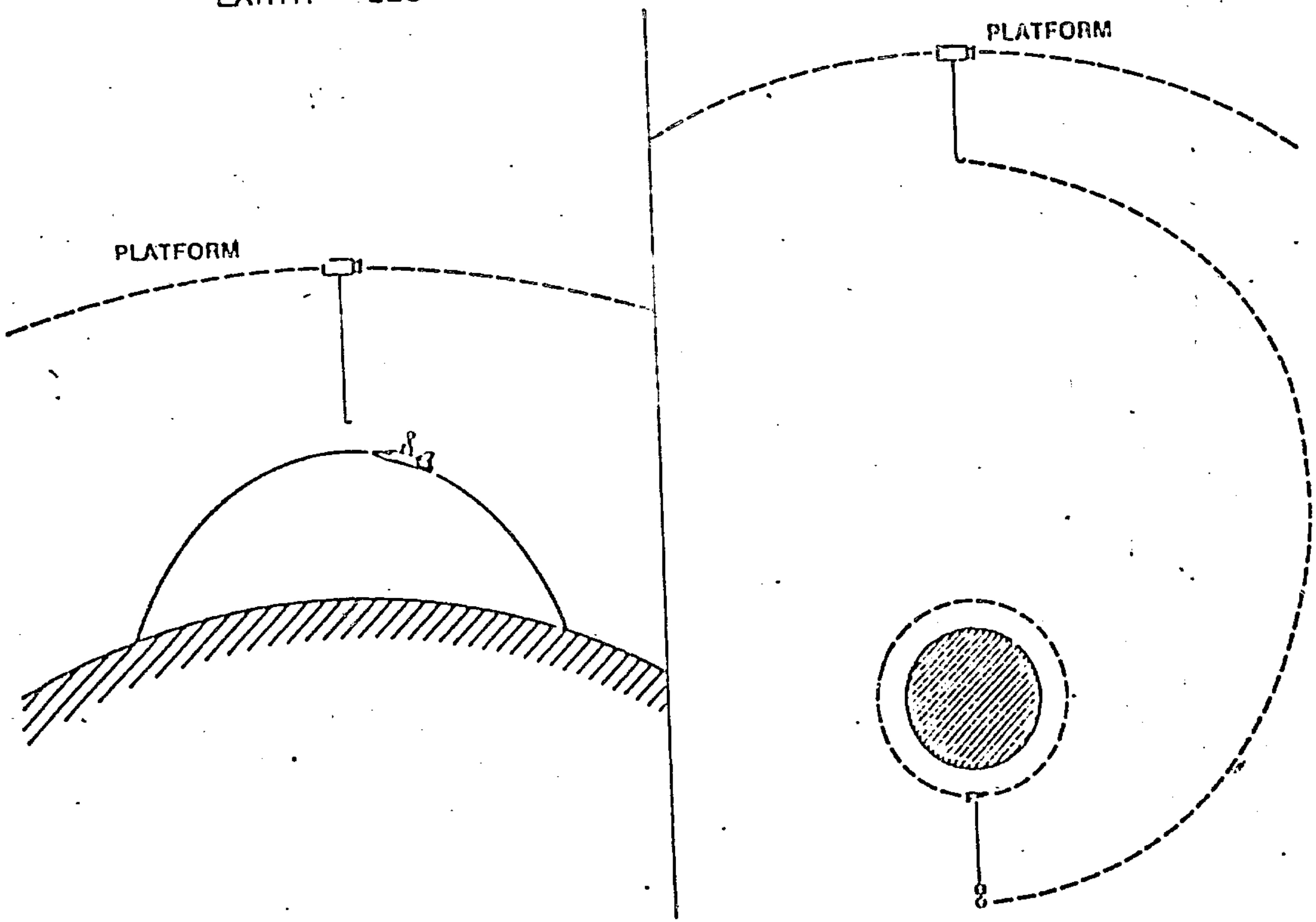


FIG. I

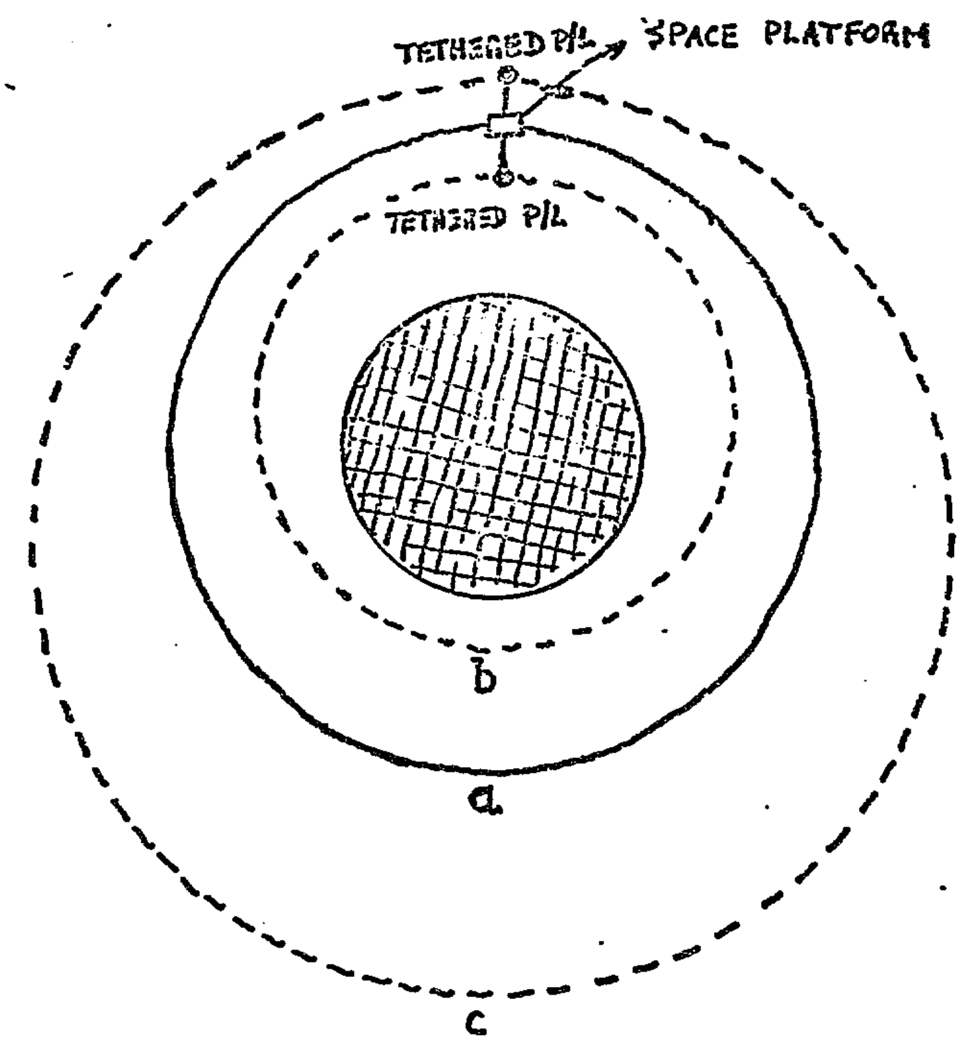
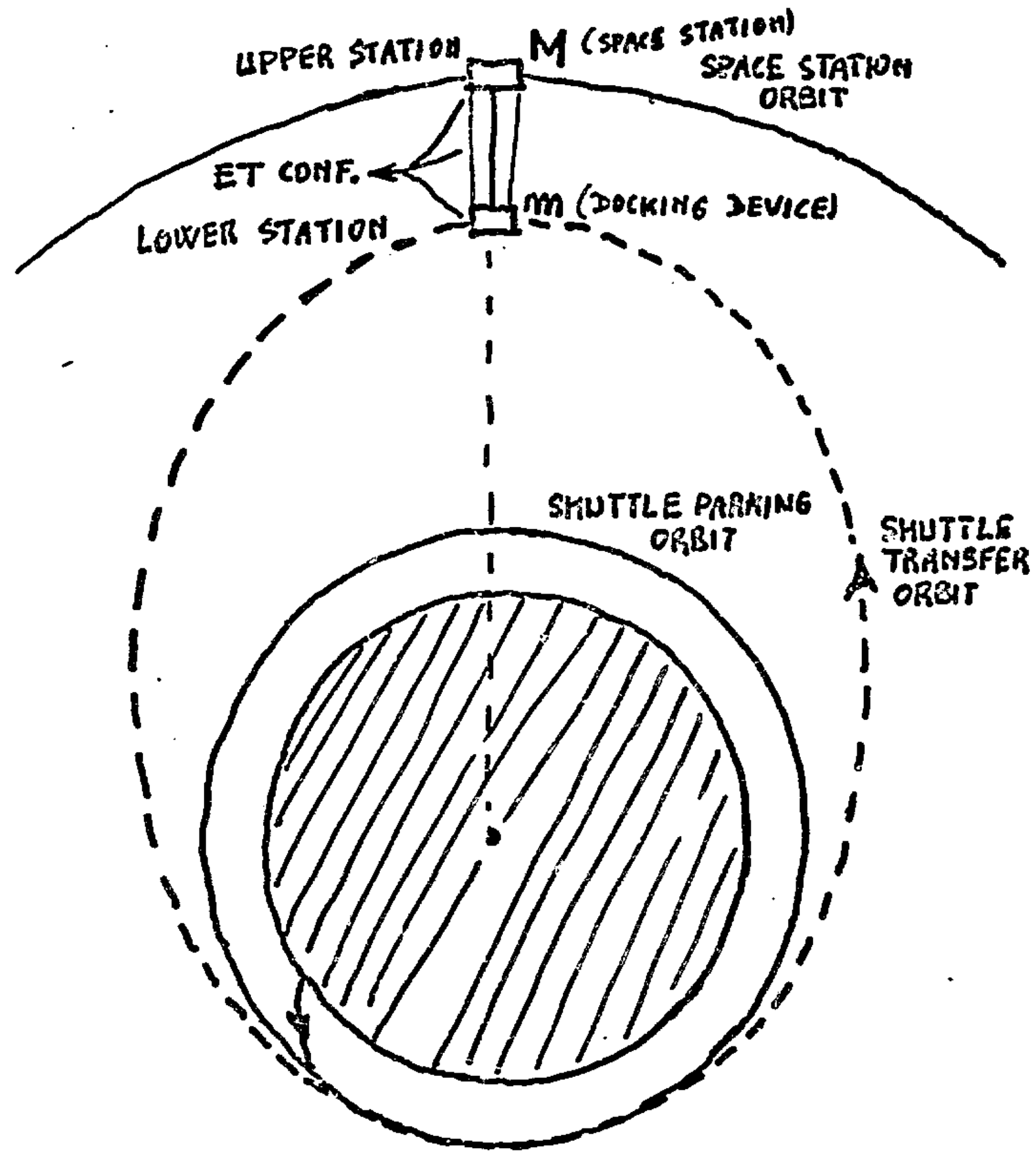


FIG. A



UPPER STATION
M (SPACE STATION)
SPACE STATION ORBIT
ET CONF.
m (DOCKING DEVICE)
LOWER STATION
SHUTTLE PARKING ORBIT
SHUTTLE TRANSFER ORBIT

FIG. B

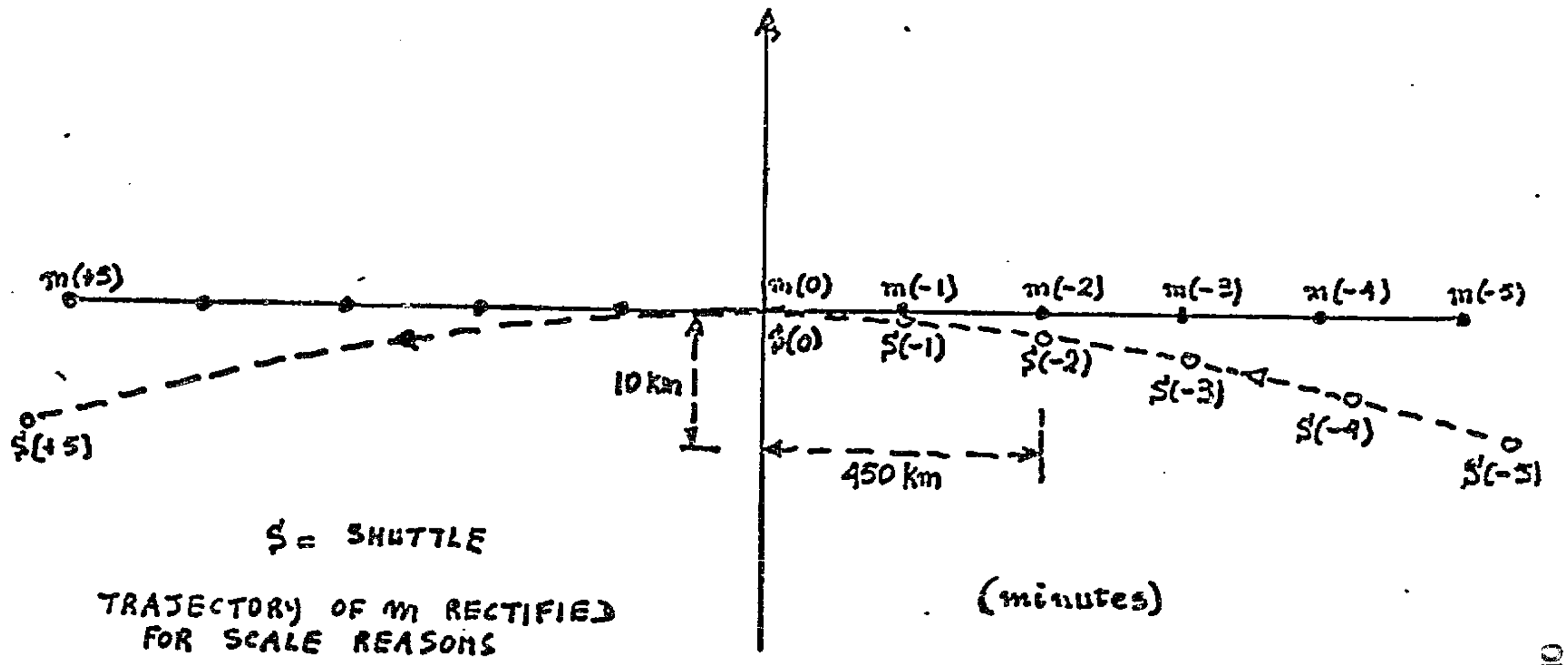


FIG. C (Relative Position, δ)

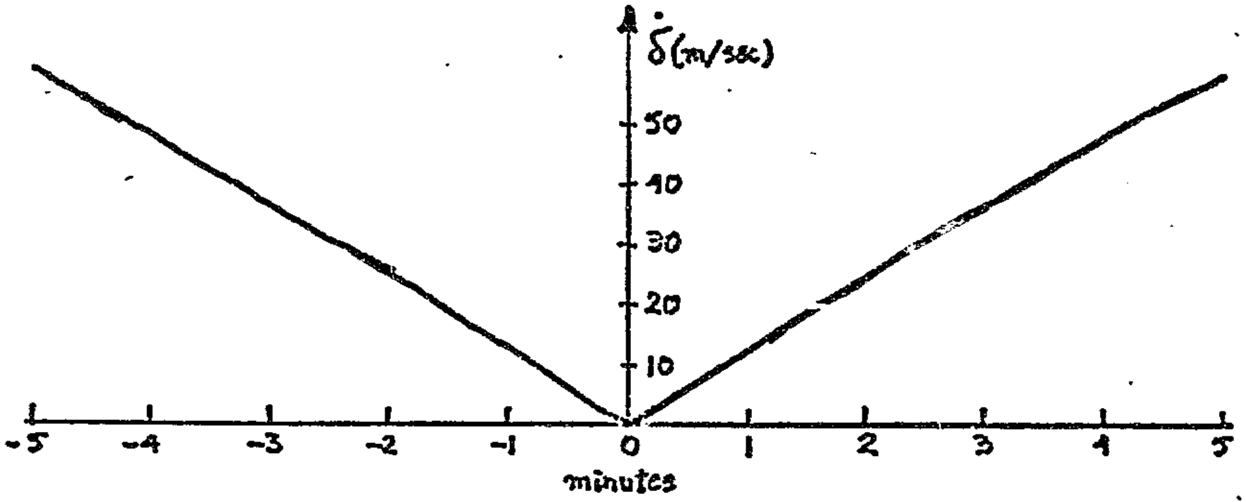


FIG. D (Magnitude of relative velocity, $\dot{\delta}$)

- SPACE STATION ALTITUDE ..... 400 Km
- SPACE STATION MASS .... 60 Ton
- TETHER LENGTH (ℓ_1) TO PROVIDE 0.1 g .... 255.21 Km

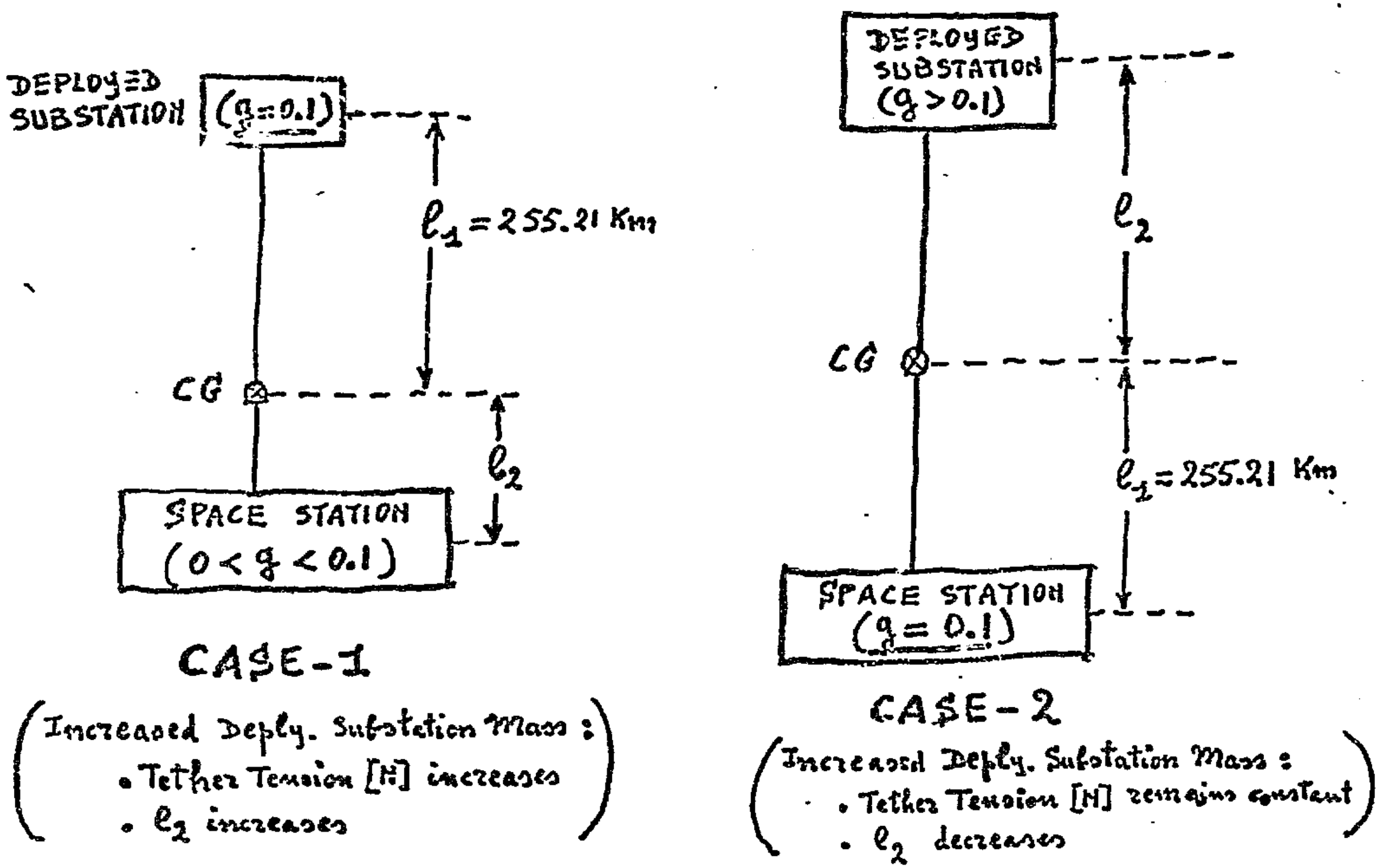


FIG. E

- TETHERED TELEOPERATOR

- CONNECTION DEVICE AMONG A MOTHER STATION AND SUBSTATIONS

- FLUID AND CARGO TRANSFER BY GRAVITY GRADIENT
  (THE GRAVITY GRADIENT IS HELPFUL FOR A TRANSFER FROM THE C.G. OF A TETHERED SYSTEM UPWARD OR DOWNWARD).

- LOW G CONTROLLED GRAVITY ACCELERATION
  (THE LOW GRAVITY ACCELERATION CAN BE VARIED AND MAINTAINED ALMOST CONSTANT IN A SUB STATION BY TETHER CONTROL).

- UNSAFE EQUIPMENT OR MATERIALS STORAGE
  (NUCLEAR POWER GENERATION OR OTHER UNSAFE PROCESSES CAN BE KEPT FAR FROM THE STATION BY A TETHER AND CAN BE RETRIEVED IF REQUIRED).

- POWER TRANSMISSION OR DATA LINK
  (THE TETHER ITSELF CAN TRANSMIT POWER OR DATA FROM A STATION TO ANOTHER CONNECTED BODY)

- AID-FACILITY FOR THE SPACE STATION ASSEMBLY
  - PROVISIONAL STABILIZATION OF CONSTITUENT PARTS
  - DOCKING DEVICE FOR CAPTURE AND RETRIEVAL OF CONSTITUENT PARTS

THE TETHER AS A STRUCTURAL ELEMENT FOR VARIOUS SPACE STATION ARCHITECTURES

- THREE BODIES CONCEPT

  A CENTRAL STATION IN THE CENTER OF GRAVITY OF THE SYSTEM (AND THEREFORE IN NATURAL ORBIT) AND TWO TETHERED PLATFORMS ALONG THE LOCAL VERTICAL ONE UPWARD AND THE OTHER DOWNWARD DEPLOYED. POSITIVE ASPECTS ARE THE ATTITUDE STABILITY AND THE SIMPLICITY OF OPERATION AS FLUIDS AND CARGO TRANSFER BY GRAVITY GRADIENT.
- ESTERNAL TANK TETHERED SPACE STATION

  (10 ÷ 15 E.T. CONSTITUTE THE LOWER PLATFORM CONNECTED TO A SIMILAR UPPER ONE WITH 20 KM LONG TETHERS)
- EXTERNAL TANK TETHERED SPACE STATION FOR A PROVISIONAL LANDING OF THE ORBITER

  (A TETHERED SPACE STATION CAN BE DESIGNED IN ORDER TO HAVE THE VELOCITY OF THE LOWER PLATFORM EQUAL TO THE APOGEE VELOCITY OF THE SHUTTLE TRANSFER ORBIT)
- CONVENTIONAL SPACE STATION STABILIZED AROUND PITCH AND ROLL AXES BY A TETHERED STABILIZATION MASS.

  THE LATTER COULD BE AN ANTENNA POINTING THE EARTH.

ADDENDUM TO THE LETTER OF AGREEMENT BETWEEN NASA AND PSN/CNR TO INVESTIGATE THE POTENTIAL APPLICATIONS OF TETHER CONCEPT TO THE FUTURE NASA SPACE STATION.

THE ADDENDUM CONSISTS OF TWO PORTIONS:

1) THE ITALIAN INDUSTRY MAY CONSULT AND/OR ASSOCIATE WITH NASA CONTRACTORS INVOLVED IN THE "SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS" STUDIES.

   NASA WILL INFORM THE INVOLVED U.S. COMPANIES OF THE PRESENT AGREEMENT.

2) NASA/SELECTED U.S. TSS CONTRACTOR - PSN/AIT JOINT INVESTIGATION ON TETHER CONCEPT APPLICATIONS TO A FUTURE NASA SPACE STATION..

   THE JOINT STUDY RESULTS IN REPORTS NOT LATER THAN THE END OF 1983, BASED ON WHICH FURTHER ACTION MAY BE DEEMED APPROPRIATE.

STS CAPABILITIES FOR SUPPORTING THE SPACE STATION PROGRAM

JAMES BRILEY

JOHNSON SPACE CENTER

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PURPOSE AND SCOPE

- TO PRESENT THE PROJECTED CAPABILITIES OF THE SPACE TRANSPORTATION SYSTEM--ASSUMING INCORPORATION OF PRESENTLY-APPROVED CHANGES--FOR SUPPORTING THE SPACE STATION PROGRAM

- TO QUANTIFY OTHER POTENTIAL IMPROVEMENTS TO THE STS THAT COULD FURTHER ENHANCE ITS CAPABILITY FOR SUPPORTING THE SPACE STATION SYSTEM

SUMMARY

- MANY OF THE STS IMPROVEMENTS OR MODIFICATIONS NOTED IN THIS PRESENTATION ARE NOT CURRENTLY PROGRAMMED AND ARE THEREFORE SUBJECT TO FUTURE FUNDING LIMITATIONS

- THE STS IS A MATURING SYSTEM THAT WILL DERIVE INCREASING CAPABILITY FOR SUPPORTING THE SPACE STATION SYSTEM THROUGH:

  - EXPERIENCE

  - PROJECTED IMPROVEMENT TO SYSTEMS

  - IMPLEMENTATION OF ADDITIONAL (E.G., SPACE STATION) REQUIREMENTS

- CONTINUING DEFINITION OF THE SPACE STATION SYSTEM WILL EVOLVE ADDITIONAL REQUIREMENTS THAT WILL PERMIT <u>FOCUSING</u> OF STS IMPROVEMENT OPTIONS AND RESOURCES

- MAS STUDIES SHOULD PROVIDE THE BASIS FOR SPACE STATION-RELATED STS IMPROVEMENT REQUIREMENTS

STS ROLE IN THE SPACE STATION PROGRAM

- SPACE STATION SYSTEM LAUNCH, ASSEMBLY, RESUPPLY AND SERVICING SYSTEM
- CREW ROTATION AND RESCUE SYSTEM
- COMMUNICATIONS INTERCHANGE
- FACILITY FOR OPERATIONAL PROCEDURES DEVELOPMENT
- TECHNOLOGY BASE FOR ON-BOARD SYSTEMS

PRESENTATION DATA BASE

STS
PROGRAM
DOCUMENTATION

STS INTERACTION
STUDIES
CONTRACT NAS 9-16193

- JSC-07700
  Vol. 10
  Vol. 14
- ORBITER VEI SPEC

OTHER PROGRAM ELEMENT
DOCUMENTATION

- IUS
- CENTAUR
- MMU
- RMS
- TMS

STS CAPABILITY - AREAS OF DISCUSSION

- LAUNCH AND LANDING WEIGHT
- ON-ORBIT STAY TIME
- RESUPPLY/RESCUE CONSIDERATIONS
- DOCKING AND BERTHING - MECHANICAL SYSTEMS
- REMOTE MANIPULATOR SYSTEM
- COMMUNICATIONS AND TRACKING
- EVA SUPPORT
- SATELLITE SERVICING
- ORBITAL TRANSFER SYSTEMS
- FLUIDS MANAGEMENT AND RESUPPLY

WEIGHT AND PERFORMANCE CAPABILITIES

- PROJECTED LIFT CAPABILITIES
- OMS KITS AND DIRECT INSERTION
- LANDING WEIGHT CONSTRAINTS

APPROXIMATE STS LIFT CAPABILITY - 28½° INCL, 150 N.M.

	PAYLOAD, LBS		
	OV 102 (AFTER MAXI-MOD)	OV 099	OV 103/104
CURRENT CAPABILITY	38,000	-	-
PROJECTED DELTA CAPABILITY WITH "APPROVED" CHANGES*	26,400	-	-
PROJECTED CAPABILITY (by 1985)	64,400	67,600	72,200
OTHER POTENTIAL INCREASES*	7,800	7,800	7,800
POTENTIAL CAPABILITY	72,200	75,400	80,000

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NOTES:
1. Stated capabilities do not allow for 3000 lb. management reserve.
2. Assumes present issues involving low MPS I_{sp} (2300 lbs), low SRB burn rate (1000 lbs) and 5.4 load (1500 lbs) are resolved.
3. Launch capabilities states are subject to Orbiter landing and launch g-load constraints.
4. Potential WTR (150 n.m., 98° incl.) lift capability is about 32,000 lbs. assuming same modifications.

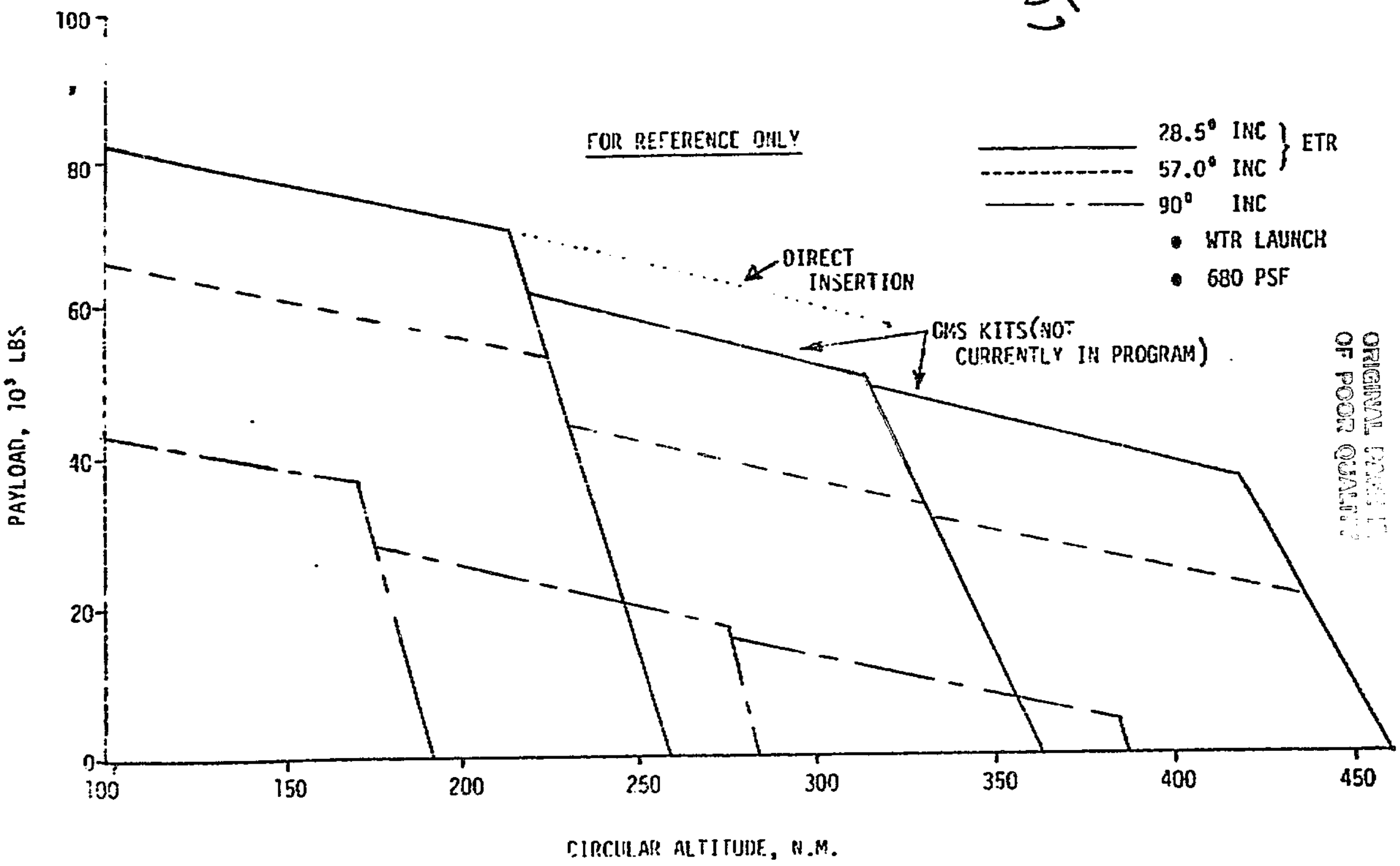
*See Chart 8 for Definition of Items

BACKGROUND CHART - LIFT CAPABILITY

- CURRENT CAPABILITY
  - 100%/100% POWER LEVEL
  - HEAVY WEIGHT ET
  - 86-80 SRB
  - 150 N.M./28.5^{0}/4 MEN/7 DAY
  - Q MAX ∼ 680 PSF

• Δ PROJECTED CAPABILITY	APPROX. Δ CAPABILITY, KLBS
• 109%/109% POWER LEVEL	10
• LIGHT WEIGHT ET	8
• FILAMENT WOUND CASE	6
• AERO UPDATE	1.4
• ET BAFFLE REMOVAL	0.9
• OTHER POTENTIAL INCREASES	7.8
• 100 N.M. VS 150 N.M.	
• 2 MEN/1 DAY	

PROJECTED SSV CAPABILITY



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ABORT LANDING WEIGHT CONSIDERATIONS

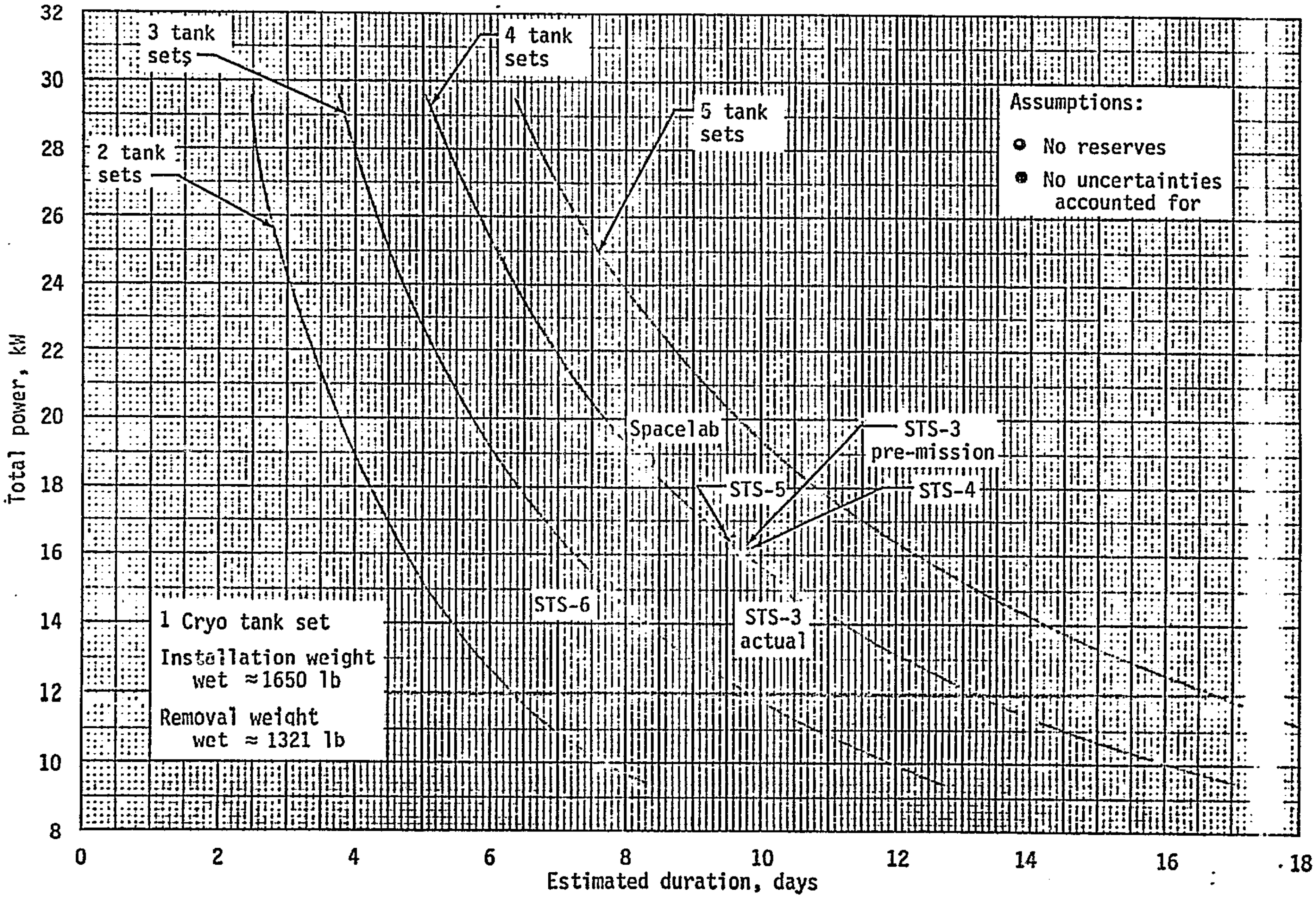
- CURRENT VEHICLE LANDING WEIGHT LIMIT (INCL. P/L WEIGHT) = 240,000 LBS
  - CORRESPONDS TO P/L LIMIT OF 43-48 KLBS.
- POTENTIAL IMPROVEMENTS COULD INCREASE PAYLOAD LANDING WEIGHT BY 10-20 KLBS.
  - LANDING GEAR SYSTEM IMPROVEMENTS
  - STRUCTURAL MODS TO MID-FUSELAGE
  - PROCEDURAL CHANGES
- NOSE GEAR EXTENSION IS MOST EFFECTIVE ITEM FOR LANDING WEIGHT IMPROVEMENT
  - NOT CURRENTLY PROGRAMMED
  - 3-4 YEARS IMPLEMENTATION LEAD TIME
  - MAY REQUIRE ADDITIONAL VEHICLE MODS TO SUPPORT WEIGHT

PERFORMANCE - SUMMARY

- SSV PAYLOAD LIFT CAPABILITY IS PROJECTED TO BE 75 - 80 K POUNDS IN THE POST - 1985 TIME PERIOD (28½° - 150 N.M. CIRCULAR ORBIT)
- ORBITER CAPABILITY TO ACCOMMODATE ASCENT, ENTRY AND LANDING LOADS FOR REQUIRED FURTHER EVALUATION
    - VEHICLE LOAD TESTS
    - LANDING GEAR MODS
    - POSSIBLE STRUCTURAL MODS
- DIRECT INSERTION CAPABILITY ATTRACTIVE FOR SPACE STATION SCENARIO
    - PLANNED FOR SOLAR MAX MISSION
    - REQUIRES FURTHER ANALYSIS FOR GENERIC USE
    - ATTRACTIVE ALTERNATIVE TO OMS KITS

ON-ORBIT STAY TIME

- FUNCTION OF:
  - NUMBER OF CRYOGENIC TANK SETS INSTALLED
  - AVERAGE ON-ORBIT POWER LEVEL
- QUIESCENT POWER LEVELS HAVE NOT BEEN ESTABLISHED
  - LOW ACTIVITY (SLEEP PERIOD) POWER LEVELS: 11-12 KW
  - CONTINGENCY POWER DOWN PERIODS: 7-8 KW
- OTHER CONSUMABLES ALSO LIMITING BECAUSE OF STORAGE CONSTRAINTS



Mission duration for EPS.

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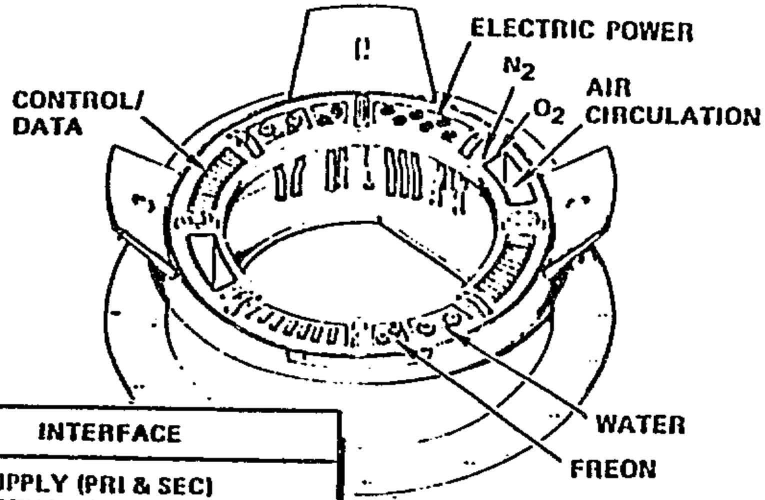
RESCUE AND RESUPPLY SUPPORT CONSIDERATIONS

- STS LAUNCH RESPONSE REQUIREMENTS
  - TURNAROUND: 2 WEEKS/160 WORKING HOURS
  - LAUNCH FROM STANDBY: WITHIN 2 HOURS
  - LAUNCH PAD HOLD CAPABILITY: 24 HOURS
- FLEET SIZE
  - FOUR ORBITERS BY - 1985
  - LONG-LEAD ITEMS FOR FIFTH ORBITER NOW FUNDED
- PROJECTED FLIGHT CAPABILITY: 24 FLIGHTS/YEAR (4 ORBITERS)
- CREW SEATING
  - FLIGHT DECK ACCOMMODATES FOUR CREW PERSONS
  - STUDIES EXPAND SEATING ACCOMMODATIONS TO 10 USING MID-DECK
    - CONCEPTUAL DESIGN ONLY; 1 - 2 YEARS FOR IMPLEMENTATION
    - DETAILED DESIGN FOR UP TO SEVEN SEATS
    - SIX CREWPERSONS ON SPACELAB 1 FLIGHT (9/83)

DOCKING AND BERTHING

- DOCKING PROVISIONS ARE REQUIRED TO SUPPORT SPACE STATION
  - NOT CURRENTLY PROGRAMMED
  - DOCKING MODULE CONCEPTUAL DESIGNS COMPLETE
  - DOCKING MECHANISMS TECHNOLOGY WORK IN PROGRESS
  - 4 - 5 YEARS IMPLEMENTATION LEAD TIME
- RMS AND OTHER MECHANICAL DEVICES REQUIRED FOR BERTHING
- VERNIER RCS ISSUE
  - ADDITIONAL UP-FIRING THRUSTERS REQUIRED FOR BRAKING
  - ADDITIONAL REDUNDANCY FOR VERNIER SYSTEM
  - NOT CURRENTLY PROGRAMMED
  - CONCEPTUAL DESIGN COMPLETE
  - 2 - 4 YEARS IMPLEMENTATION LEAD TIME

DOCKING I :RFACE CONCEPT



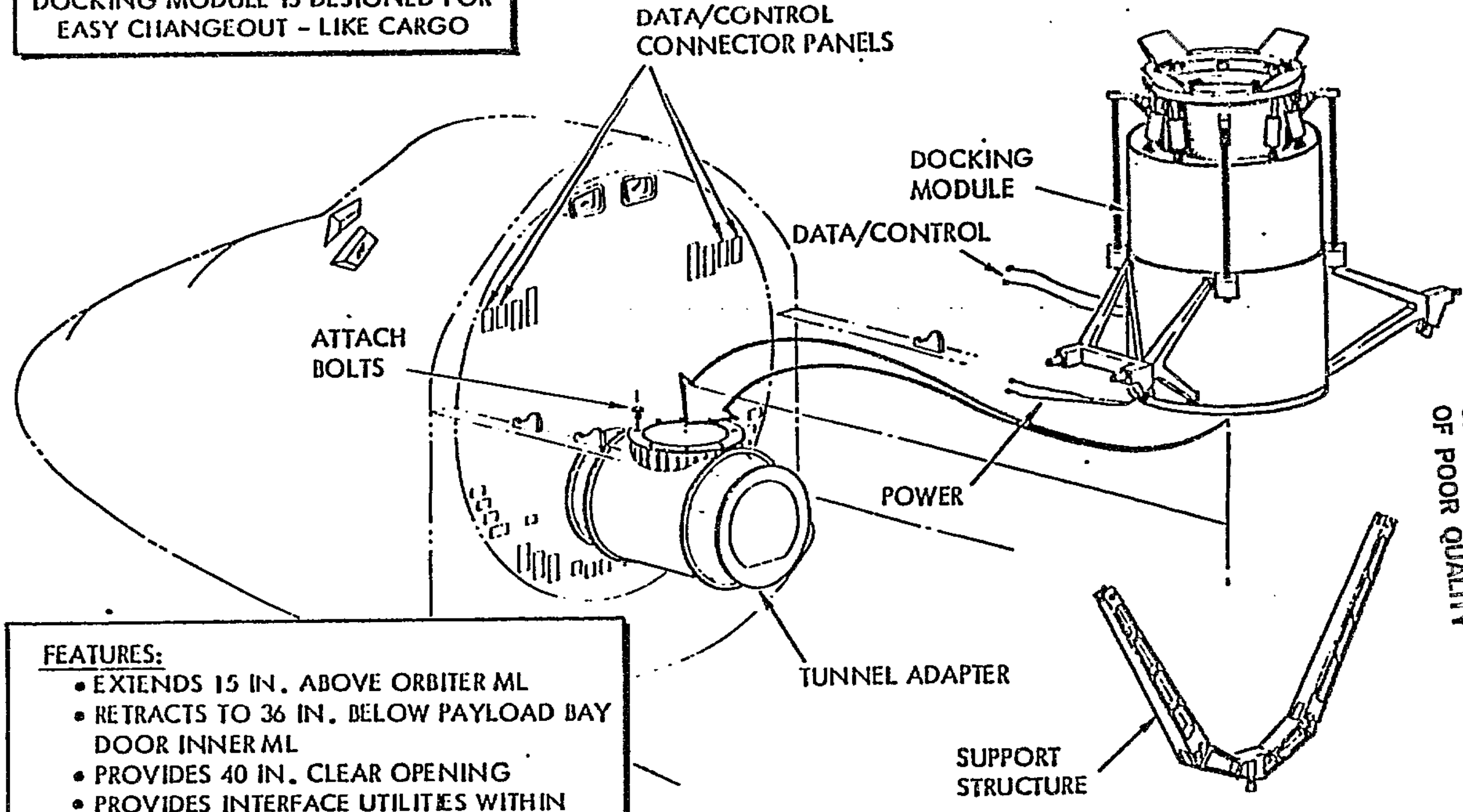
INTERFACE

FREON SUPPLY (PRI & SEC)
FREON RETURN (PRI & SEC)
H_2O COOLANT SUPPLY (PRI & SEC)
H_2O COOLANT RETURN (PRI & SEC)
H_2O COOLANT RETURN (PRI & SEC)
H_2O POTABLE SUPPLY
H_2O WASTE RETURN
O_2 SUPPLY
N_2 SUPPLY
AIR PRESSURE
AIR PROCESSING DUCTS
ELEC. POWER-PRIMARY
ELEC. POWER-SECONDARY
DATA/CONTROL
G/N-RCS
ECLSS
ISS
COMM.-AUDIO/VISUAL
DATA-DIGITAL/ANALOG

AXIAL CLOSING VEL	0.16-0.6 FPS
LATERAL VEL	≤ 0.2 FPS
ANGULAR VEL	≤ 0.6 DEG/SEC
LATERAL MISALIGNMENT	≤ 0.75 FT
ANGULAR MISALIGNMENT	≤ 5.0 DEG (ROLL)
	≤ 5.0 DEG (PITCH/YAW)

DOCKING MODULE CONCEPT

DOCKING MODULE IS DESIGNED FOR EASY CHANGEOUT - LIKE CARGO



FEATURES:

- EXTENDS 15 IN. ABOVE ORBITER ML
- RETRACTS TO 36 IN. BELOW PAYLOAD BAY DOOR INNER ML
- PROVIDES 40 IN. CLEAR OPENING
- PROVIDES INTERFACE UTILITIES WITHIN PRESSURE VOLUME
- PROVIDES ACCESS TO UTILITIES

REMOTE MANIPULATOR SYSTEM

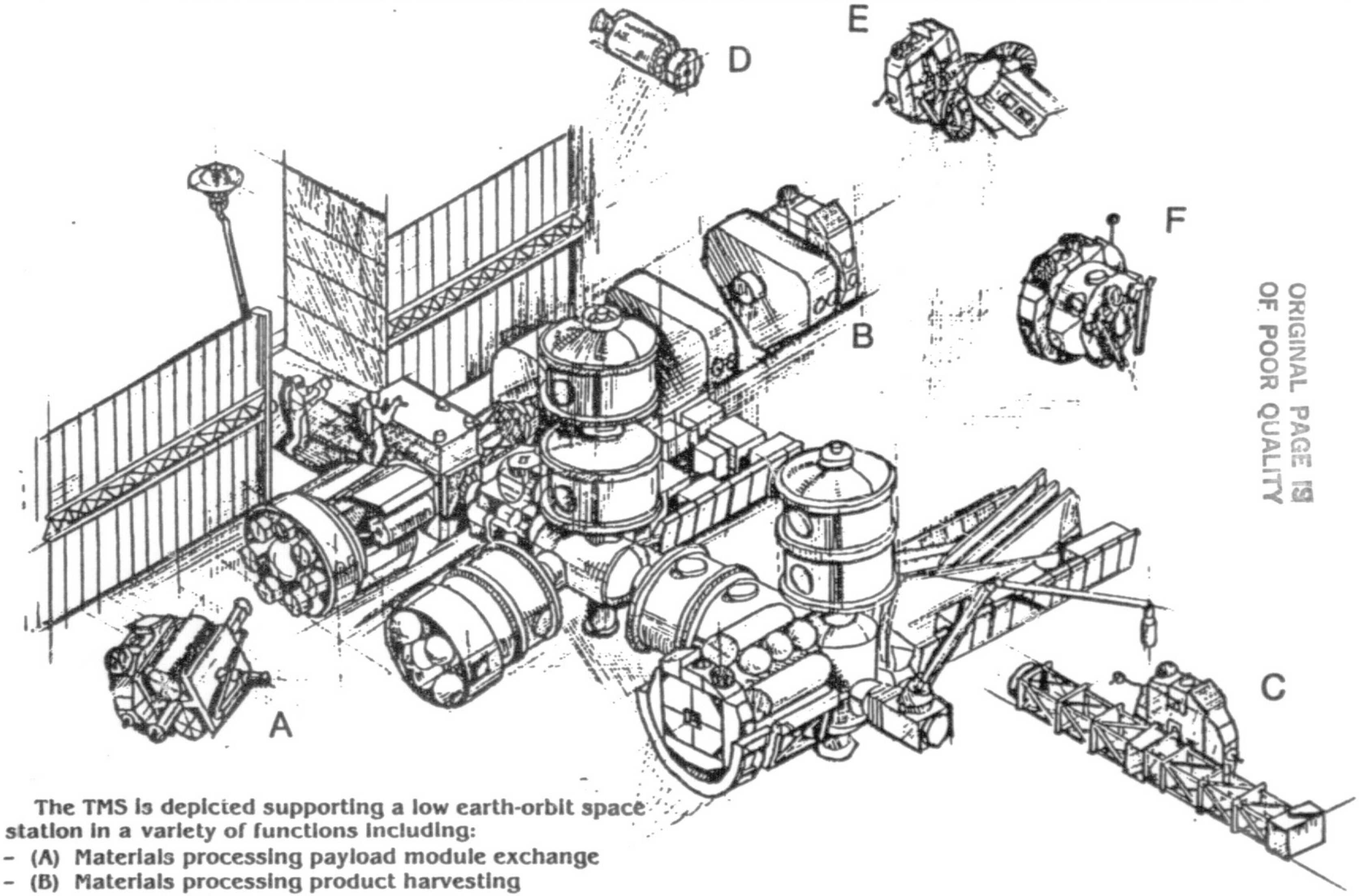
RMS DESIGN REQUIREMENTS SUMMARY

- PERFORMANCE:
  - DEPLOY/RETRIEVE 32 KLB, 15 x 60 FT PAYLOAD
  - DEPLOY 65 KLB, 15 x 60 FT PAYLOAD
  - BERTH 65 KLB PAYLOAD
  - CAPTURE PAYLOAD MOVING AT 0.1 FT/SEC. RELATIVE TO ORBITER
  - RELEASE 65 KLB PAYLOAD WITHIN ± 5^0 OF SPECIFIED ATTITUDE AND WITH ANGULAR RATES _ 0.015 DEG/SEC.
  - STOPPING DISTANCE OF 2 FT AT 0.2 FT/SEC. WITH 32 KLB PAYLOAD
  - ARM TIP VELOCITY OF 2 FT/SEC. WITH NO PAYLOAD
  - POSITION TIP OF ARM WITHIN ± 2 INCHES AND ± 1 DEGREE
  - WITHSTAND ORBITER VRCS LOADS WHILE HOLDING PAYLOAD
  - UNDER MANUAL CONTROL THE RATES OF MOVEMENT OF THE END OF THE ARM CONTROLLED WITHIN 0.03 FT/SEC. AND 0.09 DEG/SEC.
  - IN POSITION-HOLD SUB-MODE THE POSITION AND ATTITUDE OF THE END EFFECTOR MAINTAINED WITHIN ± 2 INCHES AND ± 1 DEGREE. THE LIMIT CYCLE MOVEMENT

OF EACH JOINT, WITH ZERO RATES COMMANDED BY THE OPERATOR AND NO EXTERNAL TORQUES APPLIED, SHALL BE LESS THAN 0.015 DEG/SEC.

- OTHER REQUIRED CAPABILITIES:
  - ASSIST CREW IN EXTRA VEHICULAR ACTIVITIES
  - INSPECT ORBITER AND PAYLOADS VIA CCTV
  - ASSIST IN SERVICING PAYLOADS IN CARGO BAY
  - DEPLOY AND RETRIEVE UP TO 5 PAYLOADS IN ONE MISSION
  - PLACE PAYLOADS ON A SUITABLY CONFIGURED AND STABILIZED BODY

TMS SPACE STATION SERVICES



The TMS is depicted supporting a low earth-orbit space station in a variety of functions including:

- (A) Materials processing payload module exchange
- (B) Materials processing product harvesting
- (C) Assembly of space structure
- (D) Retrieval of co-orbiting satellites for servicing
- (E) Capture of debris which may pass through space station orbits
- (F) Transport of a manned capsule

COMMUNICATIONS AND TRACKING

GLOBAL POSITIONING SYSTEM (GPS)

PURPOSE

- SATELLITE CONSTELLATION FOR USER DETERMINATION OF SELF POSITION AND VELOCITY
- USER REQUIRES COMPATIBLE "NAV SET" HARDWARE/SOFTWARE PACKAGE
- OPERATE IN L-BAND AT TWO FREQUENCIES
- ORBITERS WIRED FOR GPS RECEIVERS

PRESENT CONFIGURATION

- SIX SATELLITES IN TWO ORBITAL PLANES
- FOUR UNITS FULLY OPERATIVE
- LAUNCHED BY ATLAS VEHICLES

FINAL CONFIGURATION

- EIGHTEEN (18) SATELLITES IN SIX ORBITAL PLANES BY 1987
- LAUNCH BY STS/PAM-D's

TRACKING AND COMMUNICATION IMPROVEMENTS

ITEM	CONTENT/PURPOSE	STATUS/COMMENTS
• DIGITAL TV	• PROVIDE FOR SECURE TV TRANSMISSION • JAMMING PROTECTION	• AF FUNDING DEVELOPMENT OF PROCESSOR TO FLY ON ORBITER • OPERATIONAL: MID-TO-LATE 1980's
• KU-BAND RADAR TRANSPONDER	• TRANSPONDER ON TARGET VEHICLE • EXTENDS ORBITER KU-BAND RADAR RANGE (TRANSPONDER ON TARGET VEHICLE	• NO PRESENT FUNDING • WOULD ASSIST IN SATELLITE RENDEZVOUS, RETRIEVAL, ETC.
• LASAR TRACKER/ DOCKING SYSTEM	• PASSIVE VEHICLE-RETRO REFLECTORS • ACTIVE VEHICLE-LASER BEAM • POSITION DETERMINANT • POSITION AND ATTITUDE CLOSE IN • ENABLE AUTOMATIC OPERATIONS	• LABORATORY BREADBOARD UNIT • FLIGHT EXPERIMENT PROPOSED

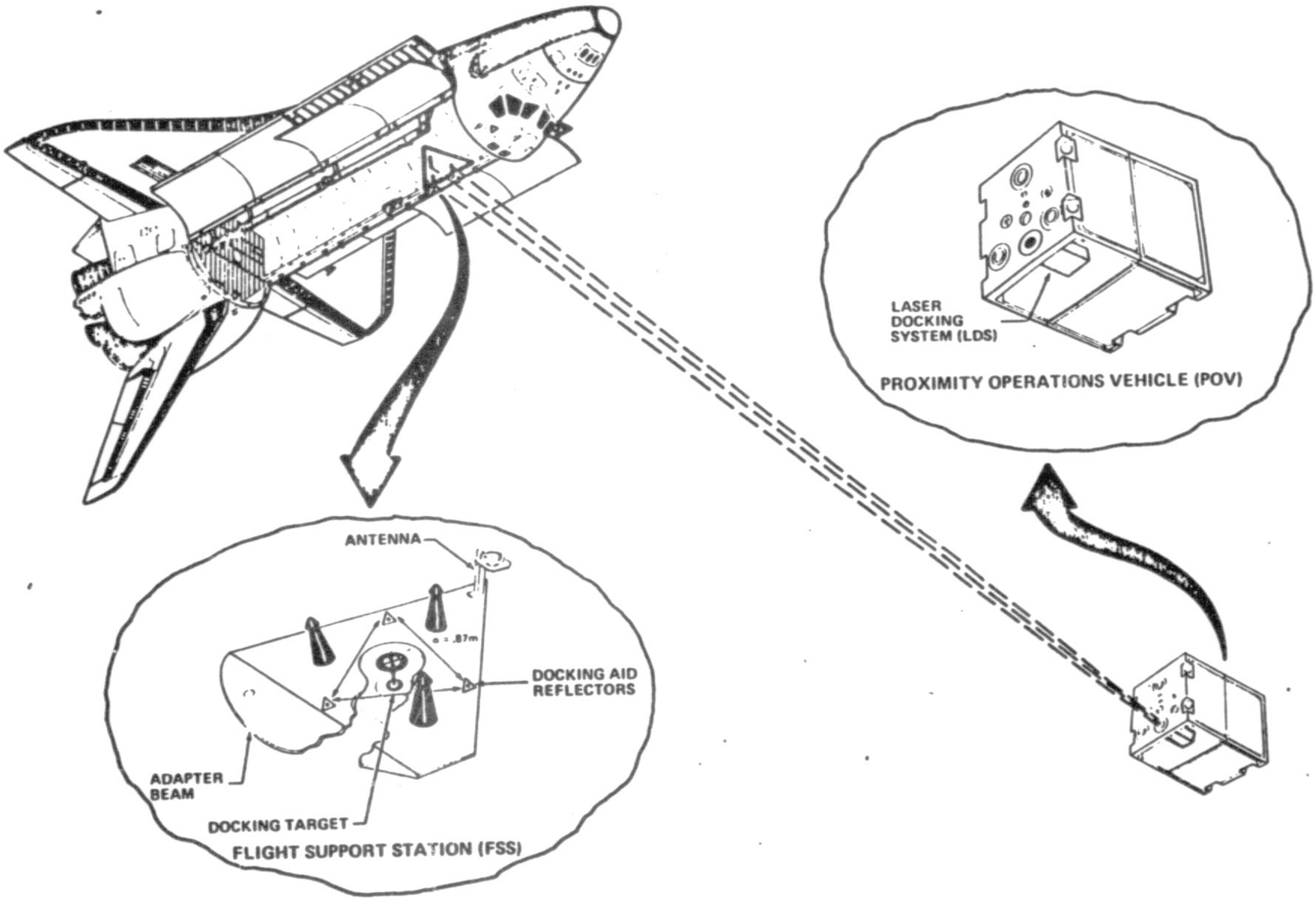
TRACKING AND COMMUNICATION IMPROVEMENTS (CONT)

ITEM	CONTENT/PURPOSE	STATUS/COMMENTS
• CLOSE-UP TV LENS	• MINUTE INSPECTION OF TARGET DETAILS	• EXPERIMENTAL VERSION ON STS-5
• INFRA-RED COMMUNICATIONS (INTERIOR)	• WIRELESS COMMUNICATION • SECURE COMMUNICATIONS • LIGHT-WEIGHT, LOW POWER, MULTIPLE CHANNELS	• LAB BREADBOARD DEMONSTRATION • PACKAGING EFFORT PROPOSED • FLIGHT DEMONSTRATION PLANNED
• LASER COMMUNICATIONS (SPACE-TO-SPACE COMM LINK)	• SECURE COMMUNICATIONS (NO SIDE OR BACK LOBES) • HIGH DATA RATE • NO RADIO INTERFERENCE	• LAB BREADBOARD
• PROXIMITY OPERATIONS RADAR	• HAND HELD RADAR - DISTANCE AND VELOCITY DETERMINATIONS	• BREADBOARD UNIT BUILT • INFRA-RED VERSION UNDER STUDY
• PROXIMITY OPERATIONS VEHICLE	• TELEOPERATOR SYSTEM - PRIMARILY FOR INSPECTION • TV, V CAPABILITY (COLD-GAS)	• DEFINITION STUDIES FY83 • PROJECTED FY84 START • OPERATIONAL 1986-88

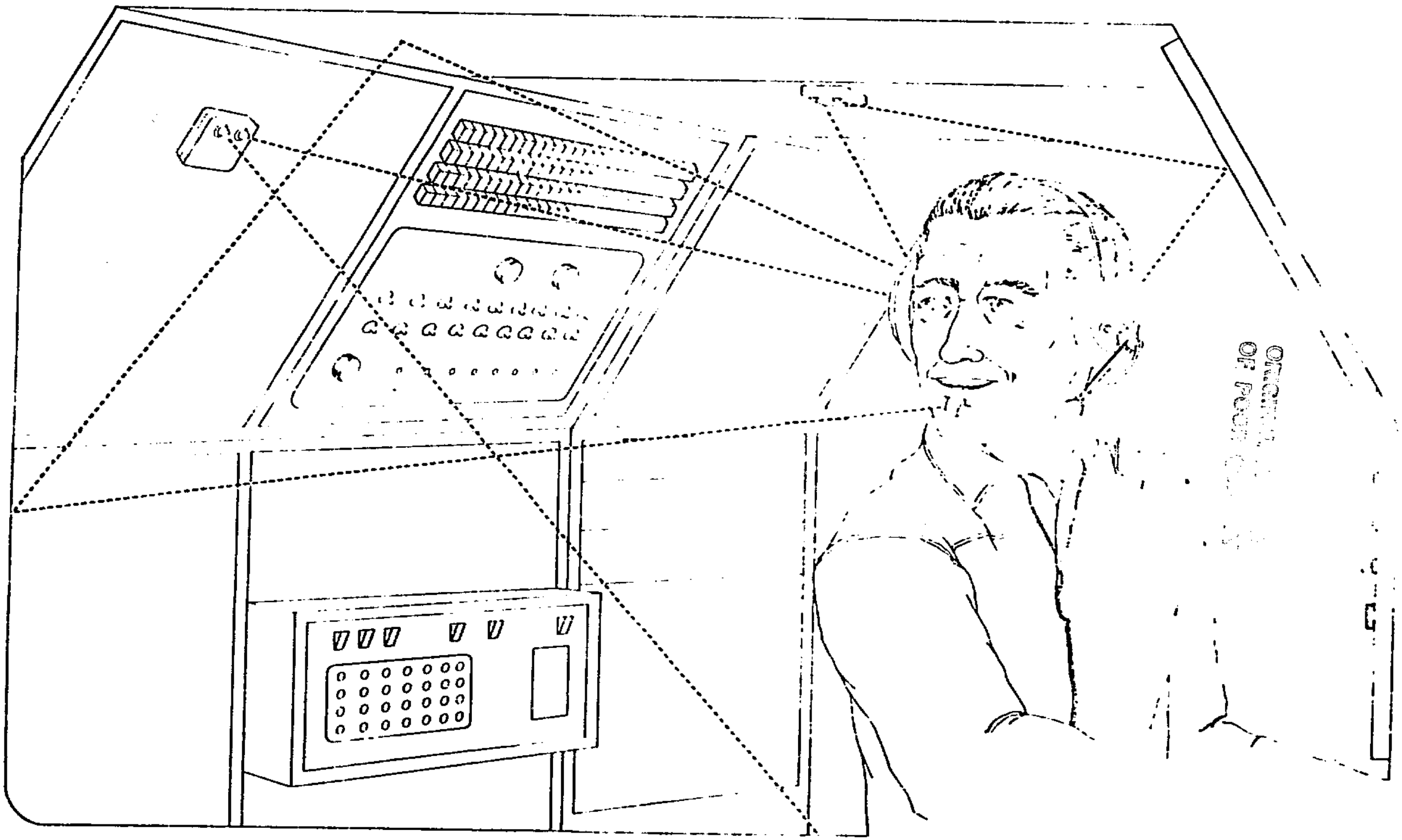
TRACKING AND COMMUNICATION IMPROVEMENTS (CONT)

ITEM	CONTENT/PURPOSE	STATUS/COMMENTS
• EMU TV	• CLOSE-UP TV FROM REMOTE LOCATIONS ENABLED BY EVA (CAMERA LOCATED ON ASTRONAUT'S HELMET) • SUPPORT ANOMALY SITUATIONS OR OTHER ACTIVITY WHERE RMS OR BULKHEAD TV CAMERAS CAN NOT VIEW SCENE OF INTEREST • REAL TIME VIEWING AVAILABLE TO GROUND THROUGH KU-BAND/TDRS LINK	• INITIAL USE ON STS-5

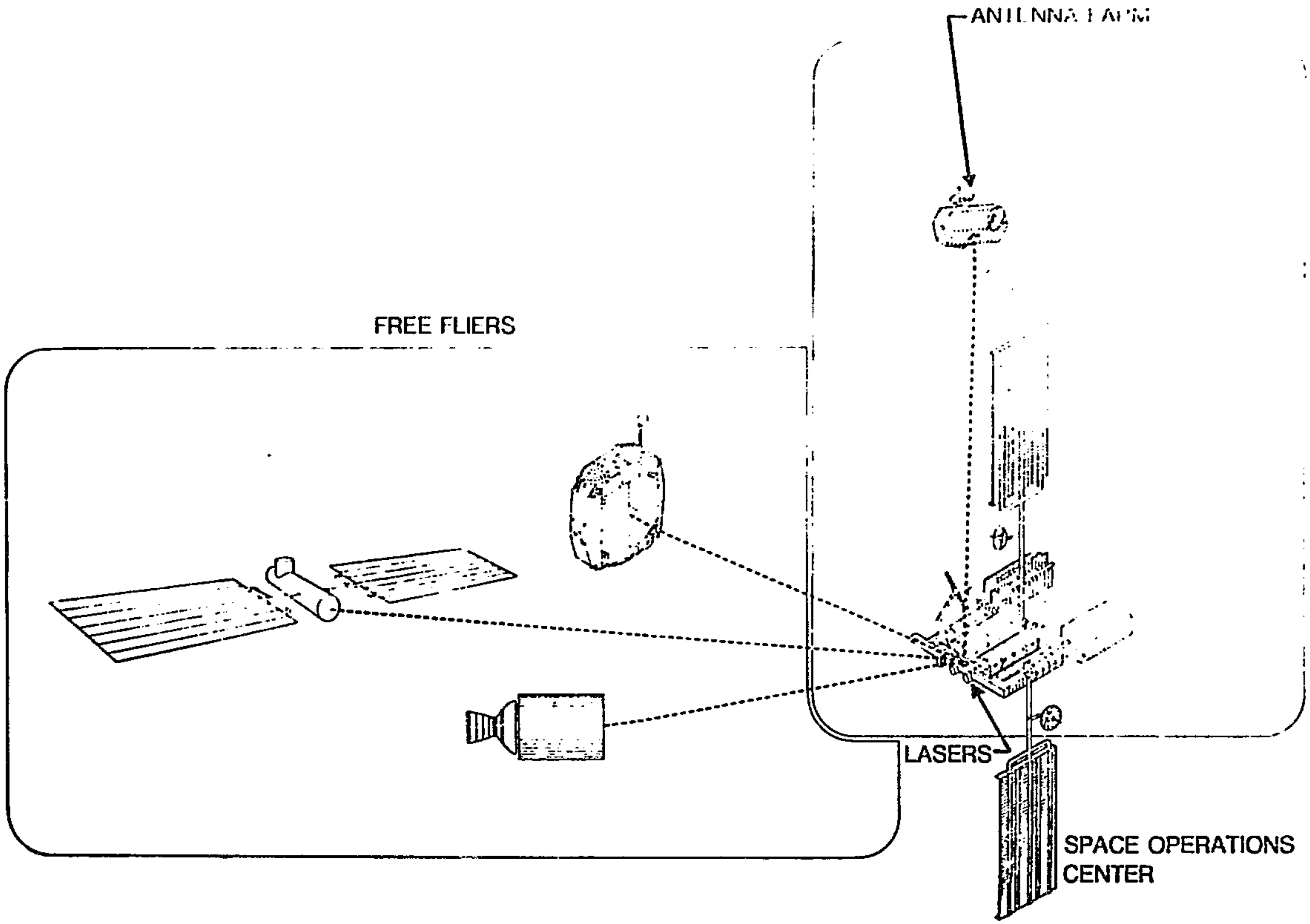
POV/LDS RENDEZVOUS AND DOCKING DEMONSTRATION WITH ORBITER



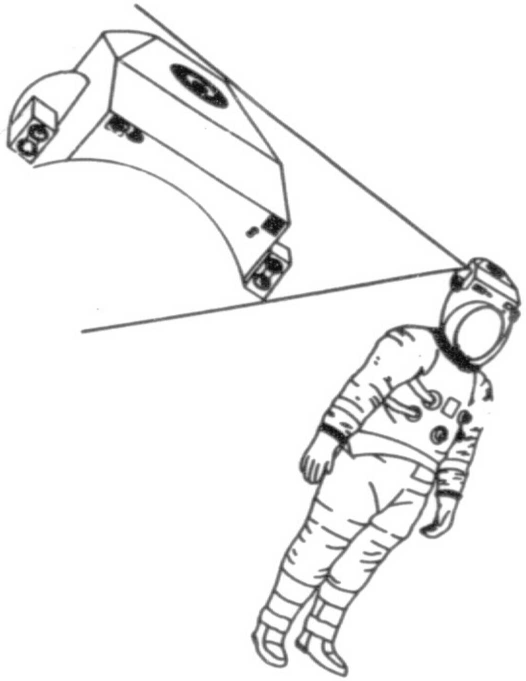
INFRA-RED CREW COMMUNICATIONS



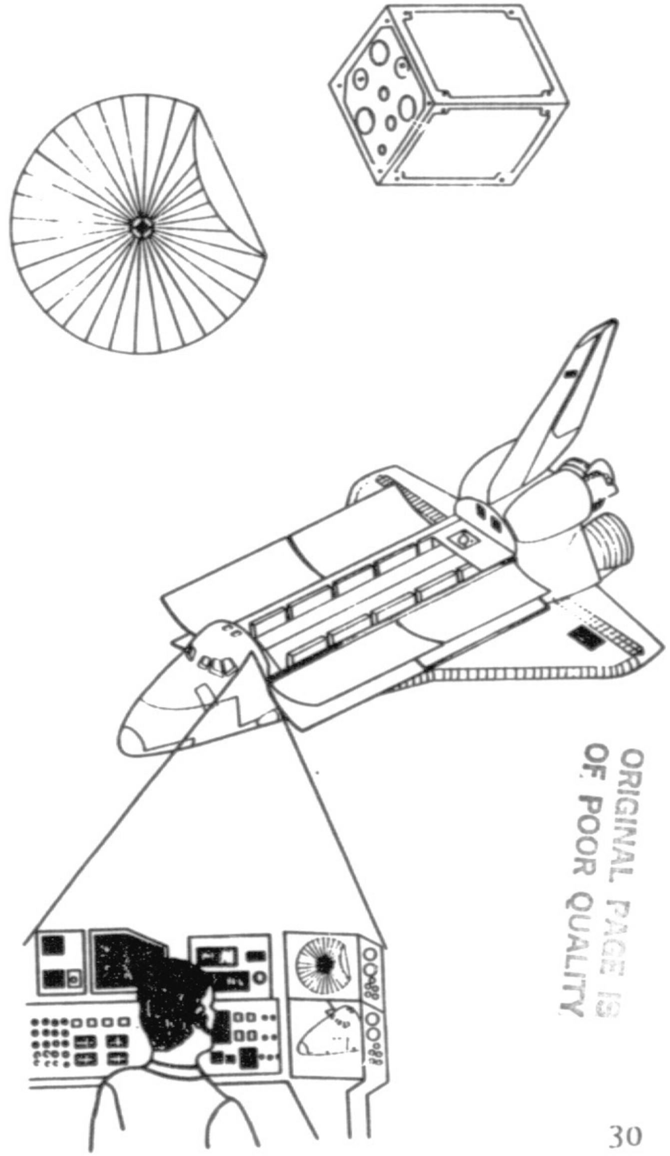
FREE SPACE LASER COMMUNICATIONS



EMU-TV ASSEMBLY



MANEUVERABLE TV (MTV)



REMOTE/DETACHED TELEVISION SYSTEMS

CREW-RELATED ISSUES

- EVA SUPPORT
- MMU CAPABILITIES
- CREW ROTATION AND RESCUE

EVA TASKS

PLANNED TASKS

ACTIVATION
ATTACHMENT
CLEANING
CONNECT
DEACTIVATE
DEPLOYMENT
DISCONNECT
EXTENSION
INSPECTION
INSTALL
MAINTENANCE
PHOTOGRAPHY
REMOVAL
RETRACTION
SERVICING
STORAGE
STOWAGE
TRANSFER

TASK ITEMS

ANTENNAS
BOOMS
CAMERAS
CARGO
EQUIPMENT MODULES
FILM CASSETTES/PACKS
INSTRUMENTATION
MATERIAL SAMPLES
OPTICAL SURFACES
PROTECTIVE COVERS
SOLAR ARRAYS
UMBILICALS
ETC.

CONTINGENCY TASKS

JETTISON
MECHANICAL OVERRIDE
REPAIR
REPLACEMENT
REPOSITIONING
RESCUE
STABILIZE
TIEDOWN

EVA EQUIPMENT INVENTORY

CREW PROVISIONS	ORBITER ACCOMMODATIONS	EVA TOOL KIT
SPACE SUITS	AIRLOCK	ADJUSTABLE WRENCH
PORTABLE LIFE SUPPORT	HANDHOLDS	RATCHET DRIVES/SOCKETS
EMU LIGHTS	FOOT RESTRAINTS	END WRENCHES
EMU TV	SLIDEWIRES	SOCKET WRENCHES
MINI WORK STATION	TETHERS	SPANNER WRENCHES
HOT PAD GLOVES	WINCHES	EXTRACTOR
COMMUNICATION CAP	STOWAGE	PRY BAR
WRIST MIRROR	EMU RESERVICING	FORCEPS
WATCH	MMU RESERVICING	PLIERS
TOOL CADDIES		SNATCH BLOCKS
SCISSORS		HAMMER
		PROBE
		VICE GRIP

EMU IMPROVEMENTS

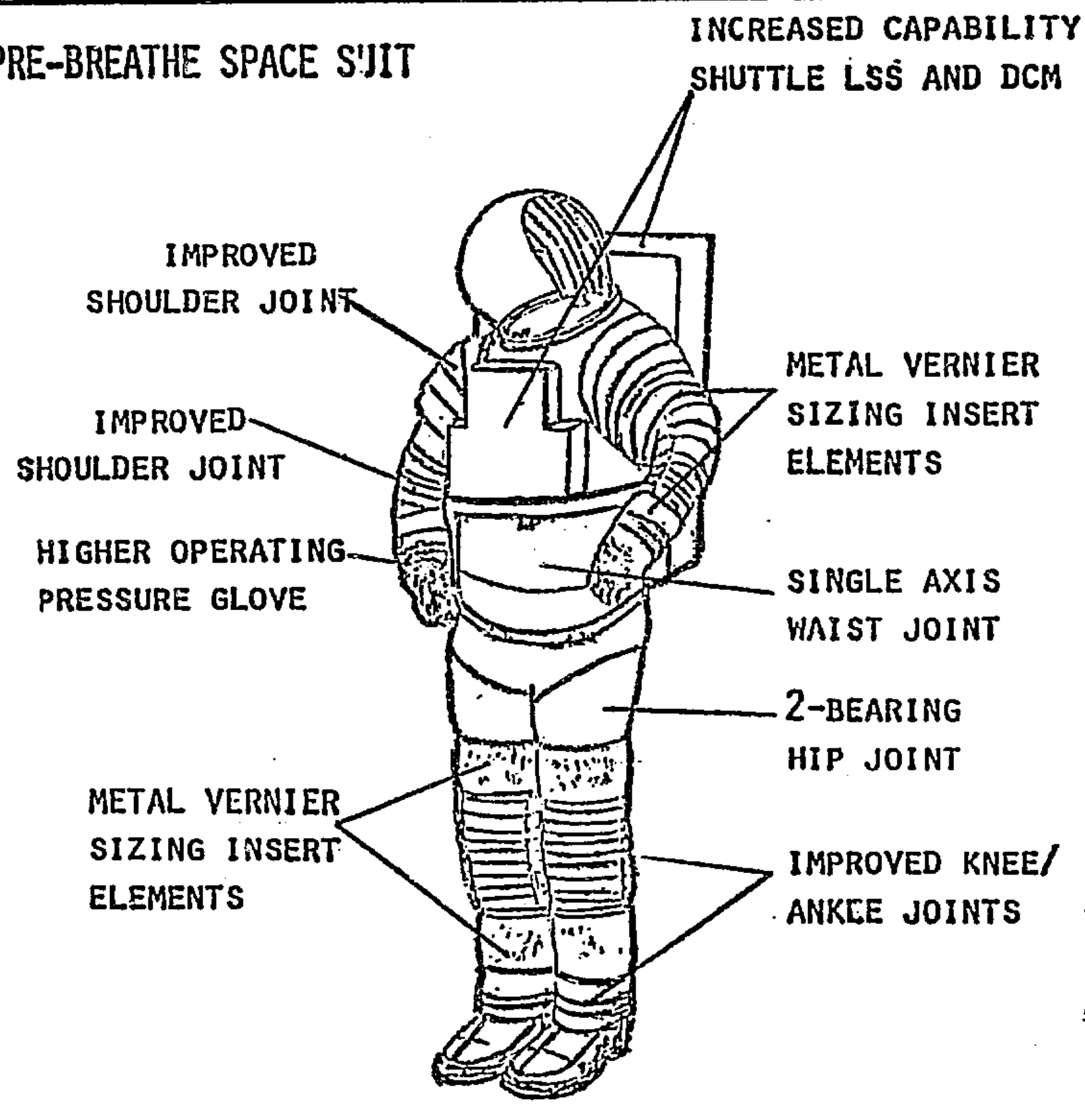
ZERO PRE-BREATHE SPACE SUIT

OBJECTIVE
HIGHLY MOBILE SPACE SUIT THAT ELIMINATES PREBREATHE

STATUS
COMPONENT TECHNOLOGY IS MATURE
INTEGRATED SUIT DESIGN INITIATED 1982

AVAILABILITY

TECHNOLOGY DEMONSTRATION	1983
PROTOTYPE DEMONSTRATION	1986
FLIGHT HARDWARE	1988



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MMU (MANNED MANEUVERING UNIT) CAPABILITIES

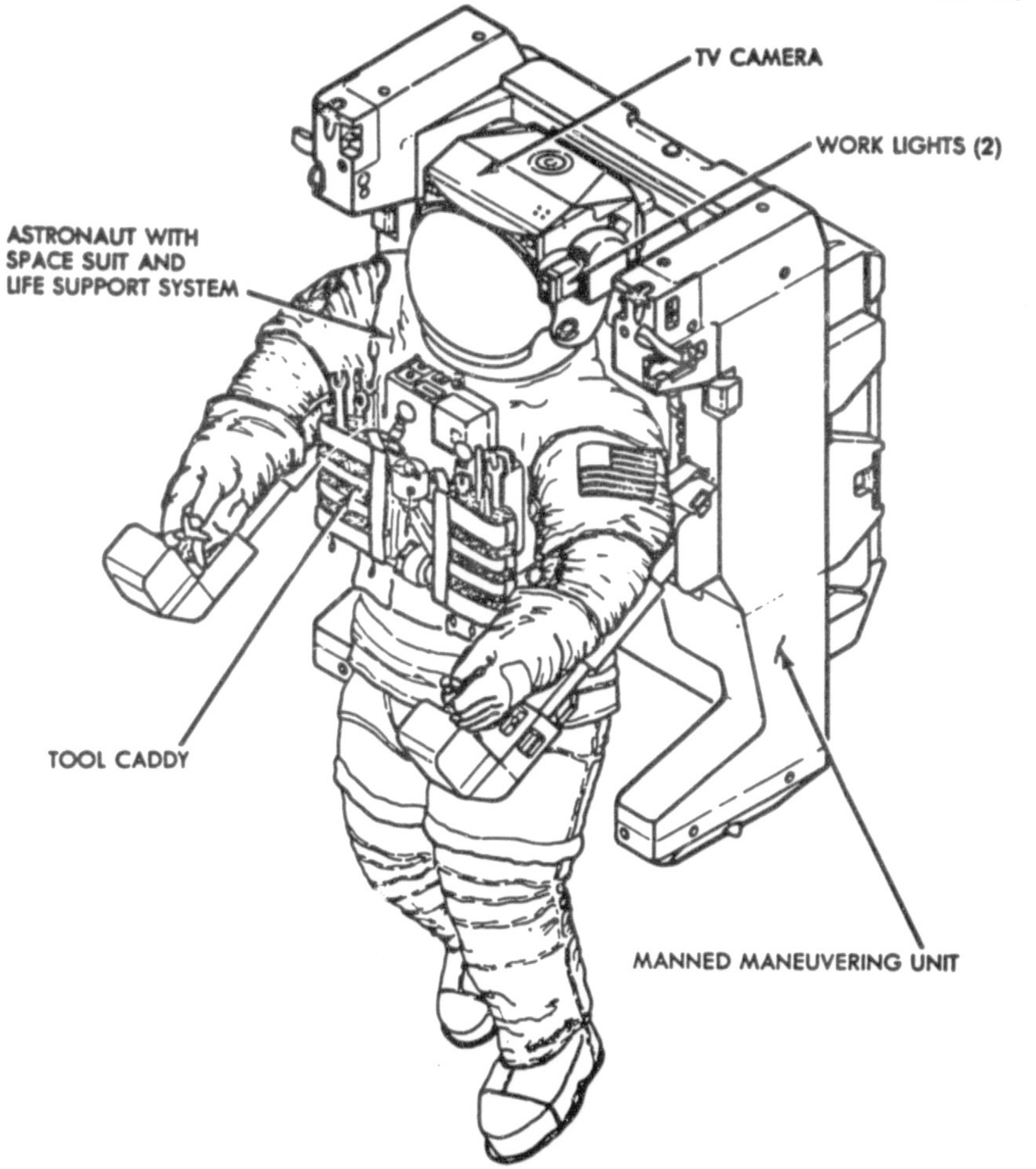
PRESENT CAPABILITIES:

- ATTACHES TO EMU
- ONE MAN SERVICE AND OPERATION
- SUPPORTS 6 HOUR EVA WITH ON-ORBIT N2 RECHARGES AS REQUIRED
- OPERATES IN VICINITY OF ORBITER
- 66 FEET/SEC DELTA VELOCITY
- MANUAL TRANSLATION AND ROTATION CONTROL WITH AUTOMATIC ATTITUDE HOLD
- CAPABLE OF TRANSFER THRU ORBITER HATCHES
- FAULT TOLERANT SYSTEM ALLOWS ISOLATION OF ANY SINGLE FAILURE AND SAFE RETURN TO ORBITER
- FSS (FLIGHT SUPPORT STATION) IN PAYLOAD BAY HOLDS MMU FOR LAUNCH, ON-ORBIT DON/DOFF/SERVICE AND REENTRY
- MMU WEIGHT 330 POUNDS, FSS WEIGHT 170 POUNDS

PROJECTED CAPABILITIES:

- INCREASED RANGE & DV DEVELOPMENT
- IMPROVE[illegible]
- IMPROV[illegible] MOMENT GYRO SYSTEM DEVELOPMENT
- HIGHER PRESSURE GN_2

EXTRAVEHICULAR SERVICEMAN



NASA
National Aeronautics and
Space Administration

S81-39352

Lyndon B. Johnson Space Center
Houston, Texas 77058

SATELLITE SERVICING

SATELLITE SERVICING

- EQUIPMENT CATEGORIES
  - INHERENT: PRESENTLY IN STS PROGRAM
  - GENERIC: GENERAL PURPOSE EQUIPMENT UNDER STUDY OR DEVELOPMEN
  - UNIQUE: SPECIAL-PURPOSE EQUIPMENT FOR SUPPORTING SPECIAL REQUIREMENTS OR MISSIONS
  - ADVANCED: EQUIPMENT POTENTIALLY NEEDED TO FULFILL PROJECTED MISSION REQUIREMENTS
- REFERENCE MATERIAL: PROCEEDINGS OF THE SATELLITE SERVICES WORKSHOP, NASA/JSC, JUNE

INHERENT EQUIPMENT: EQUIPMENT INHERENT WITH STS SYSTEM

INHERENT SERVICING EQUIPMENT	SATELLITE SERVICE FUNCTION	STATUS
PAYLOAD RETENTION SYSTEM - PRS	• PROVIDES ORBITER RETENTION (AND RELEASE) OF PAYLOADS.	AVAILABLE
REMOTE MANIPULATOR SYSTEM - RMS	• PRIMARILY FOR DEPLOYMENT AND RETRIEVAL OF SATELLITES; ALSO FOR OBSERVATION VIA CCTV AND SUPPORT SERVICES.	AVAILABLE
EXTRAVEHICULAR MOBILITY UNIT (EMU)	• PROVIDES MANNED EVA CAPABILITY.	AVAILABLE
MANNED MANEUVERING UNIT - MMU	• PROVIDES MANNED PROPULSIVE EVA CAPABILITY.	AVAILABLE
ORBITER MANEUVERING SYSTEM KIT - OMS KIT	• INCREASES ORBITER DELTA-V CAPABILITY.	ON-HOLD
AFT FLIGHT DECK - CONTROLS AND DISPLAYS	• PROVIDES CONTROL OF RMS, PRS AND OTHER REMOTE MECHANISMS FROM THE ORBITER AFT FLIGHT DECK.	AVAILABLE
EXTRAVEHICULAR MOBILITY UNIT TV	• PROVIDES CCTV DURING EVA.	AVAILABLE
CLOSED-CIRCUIT TELEVISION - CCTV	• PROVIDES CCTV VIEWING OF CARGO BAY.	AVAILABLE
ORBITER EXTERIOR LIGHTING	• PROVIDES LIGHTING OF CARGO BAY.	AVAILABLE
EQUIPMENT STOWAGE	• PROVIDES FOR THE STOWAGE OF EQUIPMENT, SPARE PARTS, TOOLS AND DEBRIS.	PARTIALLY AVAILABLE

GENERIC EQUIPMENT: EQUIPMENT WHICH INTEGRATES WITH THE INHERENT EQUIPMENT AND HAS GROWTH POTENTIAL

GENERIC SERVICING EQUIPMENT	SATELLITE SERVICE FUNCTION	STATUS
MANIPULATOR FOOT RESTRAINT - MFR	• PROVIDES A STABLE PLATFORM FOR MANNED ACTIVITY WITHIN OPERATING RANGE OF RMS.	DEVELOPMENT COMPLETED. FUNDING FOR FLIGHT HARDWARE APPROVED.
WORK RESTRAINT UNIT - WRU	• PROVIDES A METHOD OF SATELLITE ATTACHMENT AND A STABLE WORK RESTRAINT DURING MMU ACTIVITY.	DEVELOPMENT PARTIALLY COMPLETE.
MANEUVERABLE TELEVISION - MTV	• PROVIDES REMOTE SATELLITE (AND ORBITER) OBSERVATION CAPABILITY.	LIMITED DEVELOPMENT ACTIVITY UNDERWAY.
HOLDING AND POSITIONING AID - HPA	• PROVIDES TEMPORARY HOLDING AND POSITIONING OF A SATELLITE WHILE BEING SERVICED	FABRICATION OF TEST MODEL FOR 1-G TESTING UNDERWAY.
FLUID TRANSFER EQUIPMENT/TECHNIQUES	• PROVIDES CAPABILITY TO TRANSFER FLUIDS BETWEEN THE ORBITER AND SATELLITES.	CONCEPT ONLY
TOOLS: POWER/HAND	• ENHANCES MANNED ACTIVITY DURING EVA.	PARTIALLY AVAILABLE
RMS GENERAL PURPOSE END EFFECTORS	• ENHANCES RMS CAPABILITY	CONCEPT ONLY

UNIQUE EQUIPMENT: EQUIPMENT UNIQUE TO SPECIAL MISSION REQUIREMENT

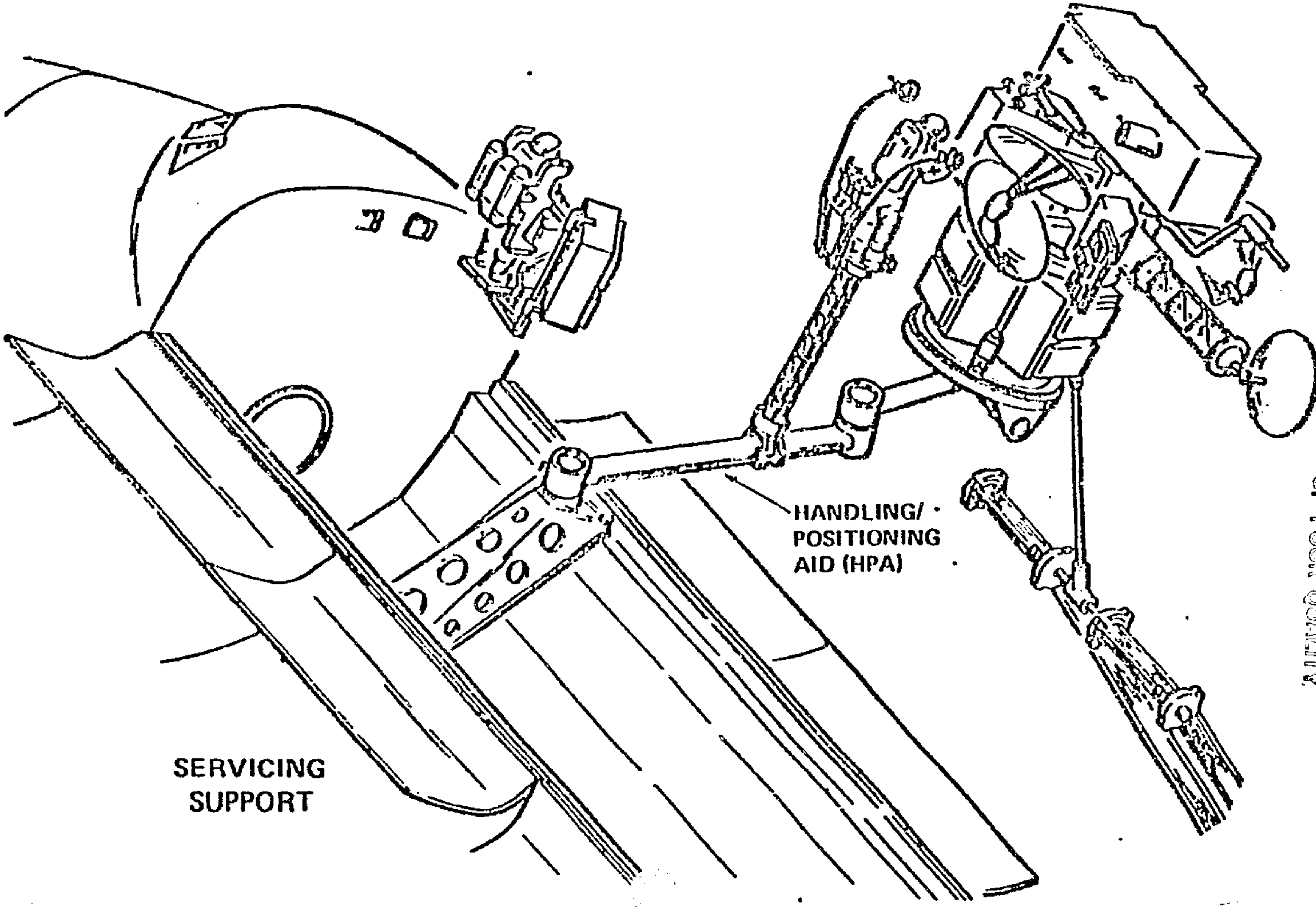
UNIQUE SERVICING EQUIPMENT	SATELLITE SERVICE FUNCTION	STATUS
PAYLOAD INSTALLATION AND DEPLOYMENT AID	• ALLOWS CONTROLLED DEPLOYMENT AND STOWAGE OF MAXIMUM SIZED PAYLOADS WITH MINIMAL RISK OF DAMAGE TO THE ORBITER AND PAYLOAD.	1-G TEST MODEL EVALUATED.
PAYLOAD HANDLING DEVICES	• PROVIDES CAPABILITY TO GRAPPLE AND HANDLE UNATTACHED PAYLOADS.	STUDY UNDERWAY FOR SOLAR MAX REPAIR MISSION.
RMS SPECIAL PURPOSE END EFFECTORS	• ENHANCES THE CAPABILITY OF THE RMS.	CONCEPT ONLY
TILT TABLE	• PROVIDES THE PROPER ORIENTATION OF PAYLOADS FOR DEPLOYMENT, BERTHING AND/OR SERVICING.	CONCEPT ONLY
SPIN TABLE	• PROVIDES THE CAPABILITY TO "SPIN-UP" SATELLITE PRIOR TO DEPLOYMENT.	CONCEPT ONLY

ADVANCED EQUIPMENT: EQUIPMENT POTENTIALLY NEEDED TO FULFILL FUTURE MISSION MODEL REQUIREMENTS

ADVANCED SERVICING EQUIPMENT	SATELLITE SERVICE FUNCTION	STATUS
TELEOPERATOR MANEUVERING SYSTEM	• PROVIDES FOR PAYLOAD DELIVERY/RETRIEVAL TO/FROM SATELLITE OPERATIONAL ORBIT WHEN DIFFERENT FROM ORBITER ORBIT.	STUDIES UNDERWAY
NON-CONTAMINATING ATTITUDE CONTROL SYSTEM	• ALLOWS SERVICING OF CONTAMINATION SENSITIVE SATELLITES.	CONCEPT ONLY
SUN SHIELD	• PROVIDES PROTECTION TO SUN SENSITIVE PAYLOAD.	CONCEPT ONLY
ORBITAL STORAGE	• PROVIDES ENVIRONMENTAL PROTECTION FOR ON-ORBIT QUIESCIENT "STORAGE" OF SATELLITES.	CONCEPT ONLY
OPTICAL ATTITUDE TRANSFER SYSTEM	• MEASURES PAYLOAD BAY DISTORTION RELATIVE TO THE INERTIAL MEASUREMENT UNIT (IUM) PLATFORM, HENCE TRANSFERRING ATTITUDE REFERENCE TO SATELLITES MORE ACCURATELY.	CONCEPT ONLY
LIGHTING ENHANCEMENT	• ENHANCES LIGHTING CAPABILITY.	CONCEPT ONLY
DEXTEROUS MANIPULATOR	• ENHANCES REMOTE "TELEOPERATOR" SERVICE CAPABILITY.	LIMITED STUDY UNDERWAY
DE-ORBIT PROPULSION PACKAGE	• PROVIDES THE CAPABILITY TO DE-ORBIT AND PROPEL EXPENDABLE SATELLITES TO EARTH.	CONCEPT ONLY

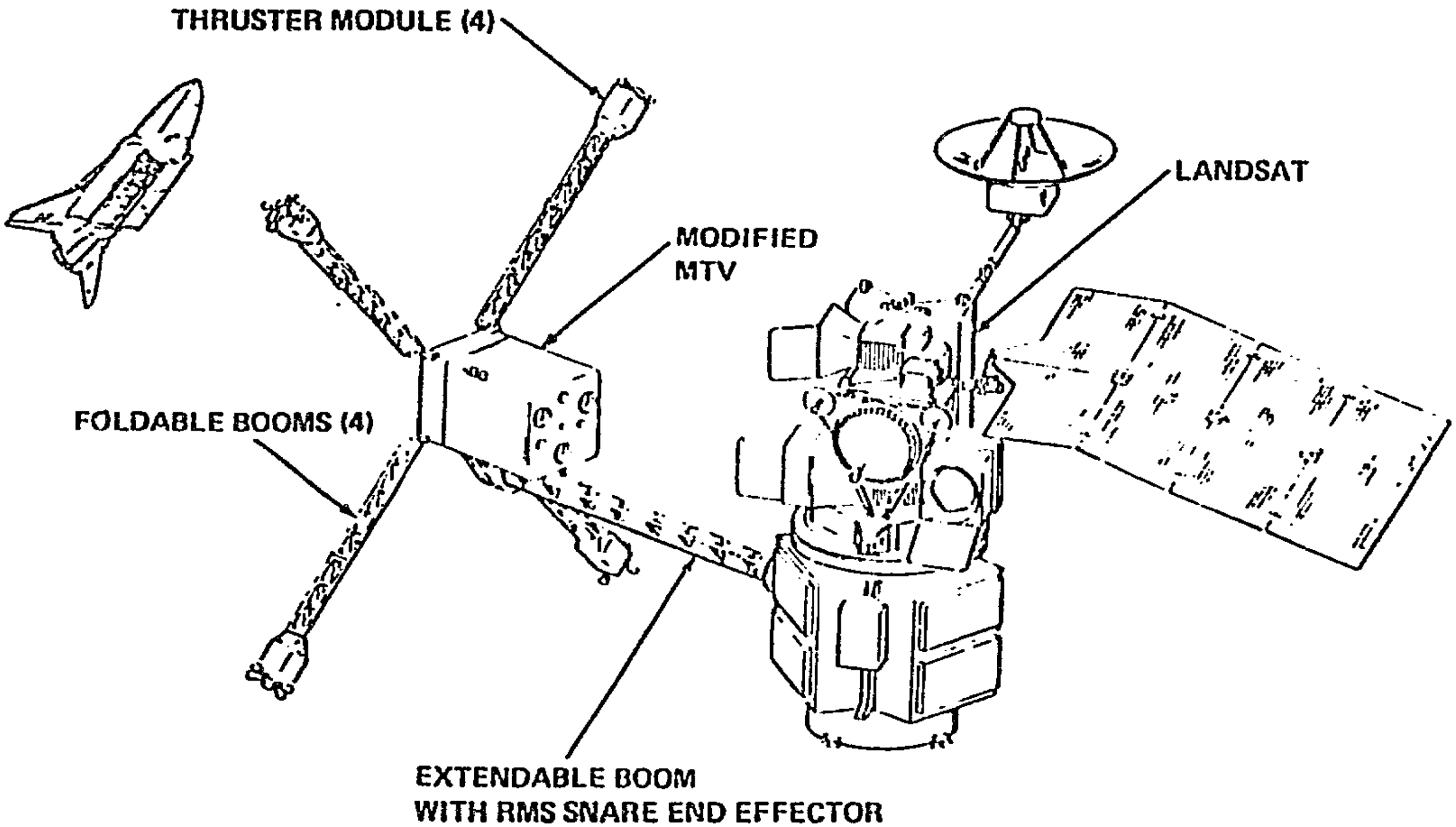
MANNED MANEUVERING UNIT/WORK RESTRAINT UNIT (MMU/WRU) ADAPTATIONS

PAYLOAD HANDLING

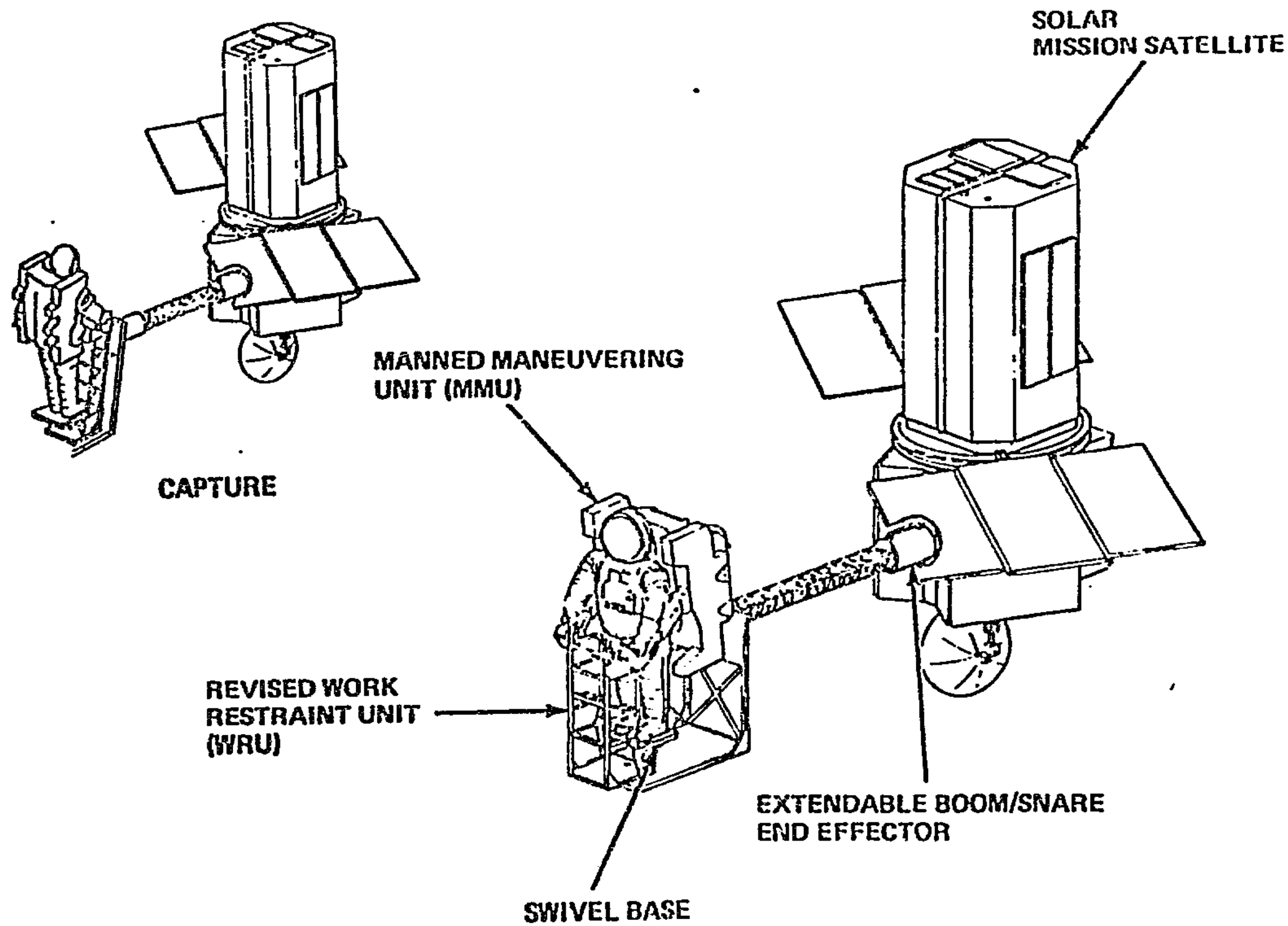


PROXIMITY OPERATIONS MODULE (POM) – MTV ADAPTATION

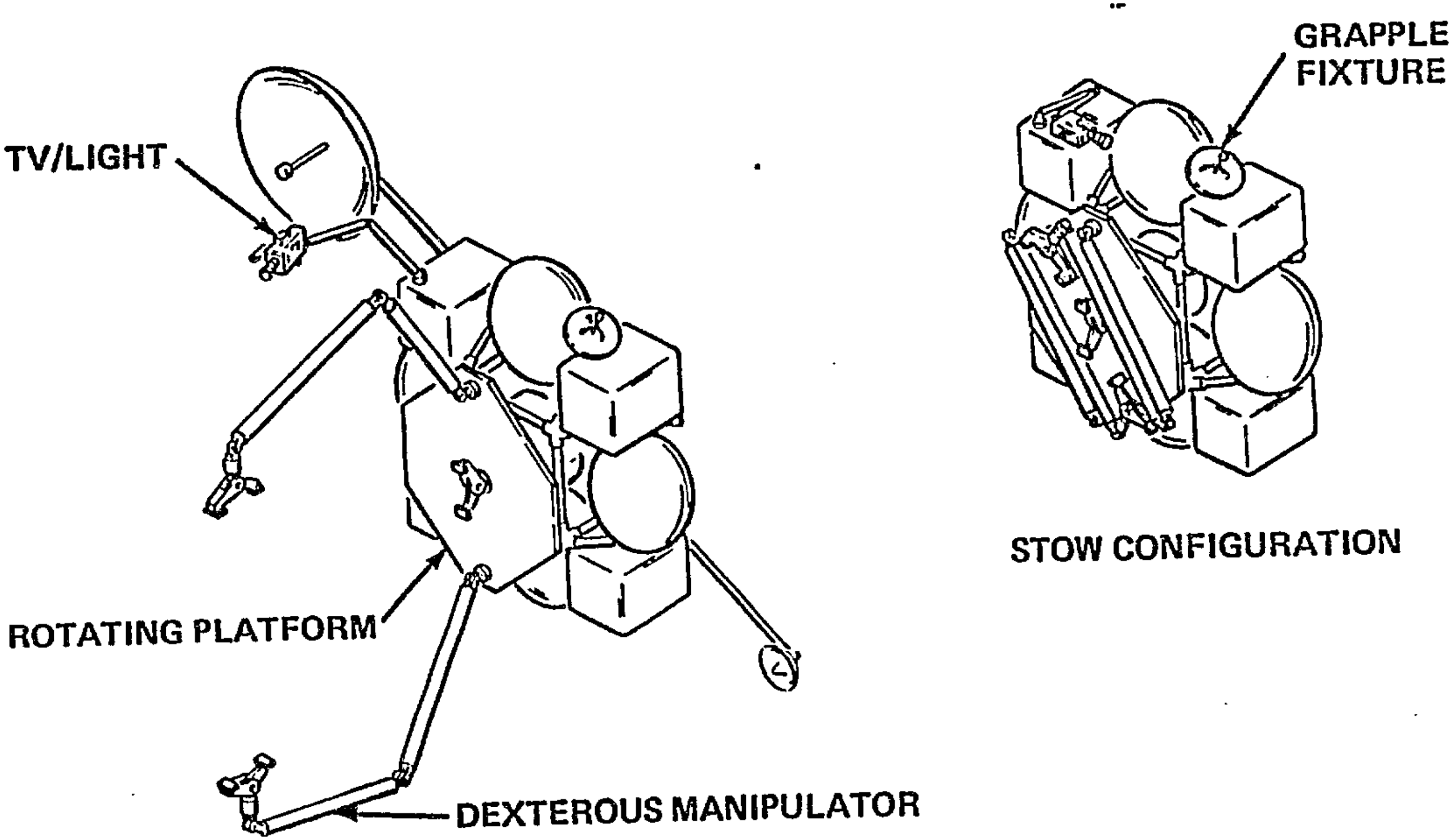
- RETRIEVAL OF SATELLITES WITHIN 1000' OF ORBITER
- FLIGHT CONTROL VIA CREW IN ORBITER AFD



PROXIMITY OPERATIONS MODULE (POM) — WRU ADAPTATION



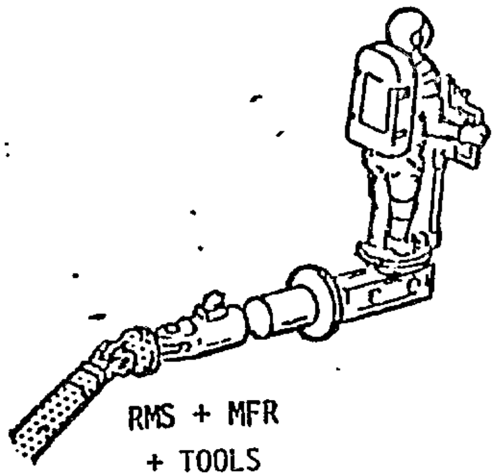
VERSATILE SERVICE ST. .GE (VSS) – DEBRIS RETRIEVAL



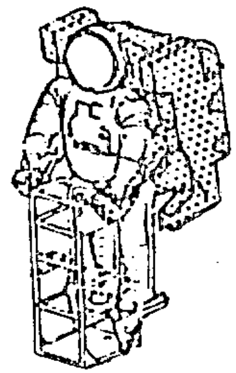
DEPLOYED CONFIGURATION

STOW CONFIGURATION

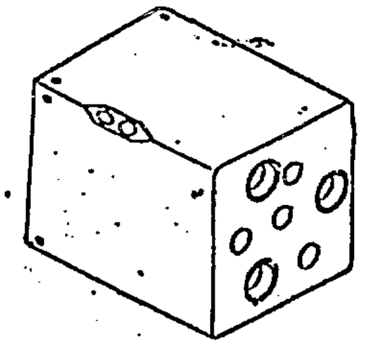
SATELLITE SERVICES SYSTEM OVERVIEW EVOLUTIONARY GROWTH POTENTIAL	PROGRAM DEVELOPMENT OFFICE	
	GORDON RYSAVY	



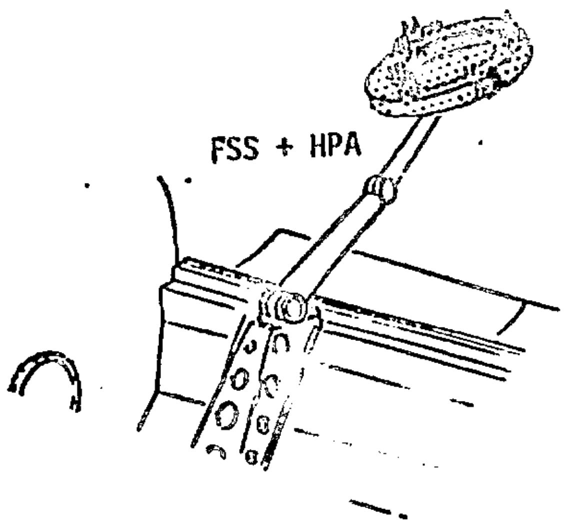
RMS + MFR
+ TOOLS



MMU + WRU

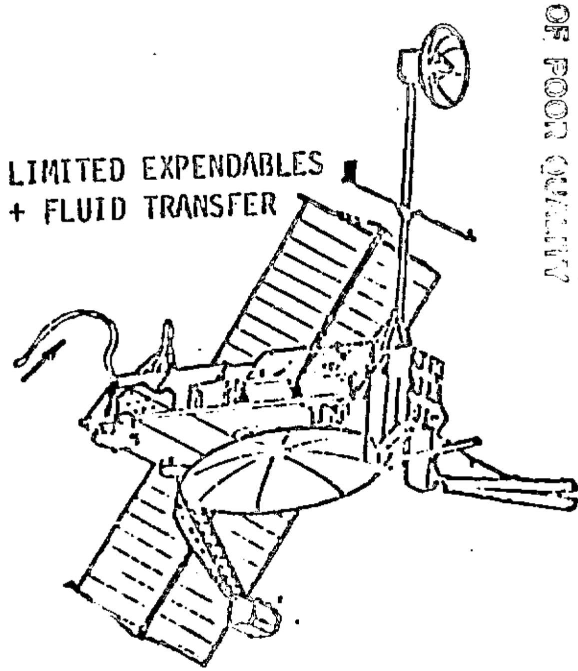


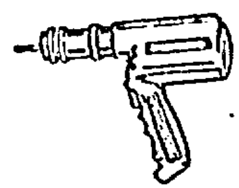
CCTV + MTV



FSS + HPA

LIMITED EXPENDABLES
+ FLUID TRANSFER





HAND TOOLS +
POWER TOOLS

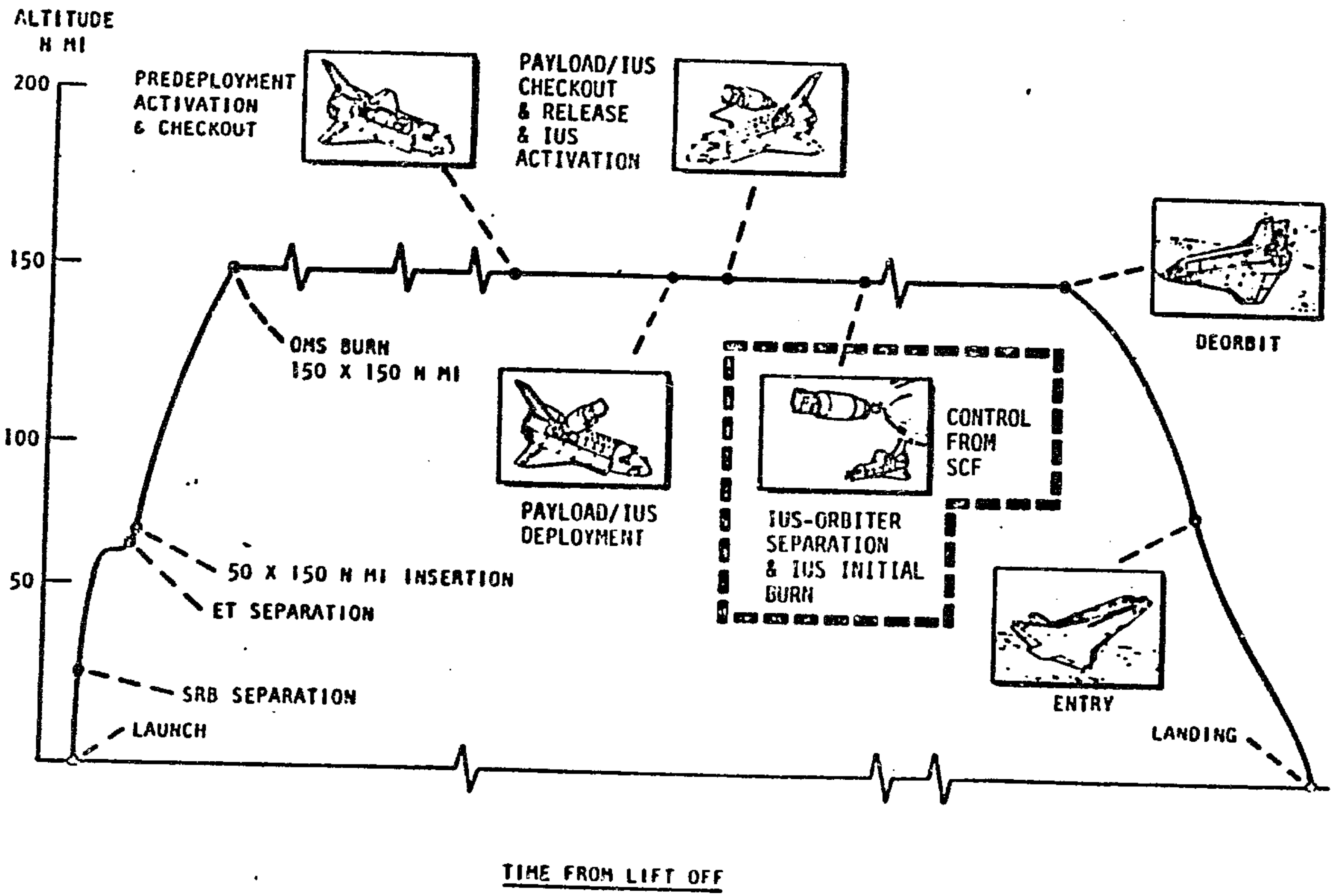
ORBITAL TRANSFER SYSTEMS

INERTIAL UPPER STAGE (IUS)

- IUS: 2-STAGE SOLID ROCKET INERTIALLY STABILIZED UPPER STAGE
- LAUNCHED VIA TITAN (REPLACES TRANSTAGE) OR STS
- PAYLOAD CAPABILITY
  - 5000 LBS TO GEO FROM 150 N.M. PARKING ORBIT
  - INTERPLANETARY VERSION CANCELLED
- PHYSICAL DATA
  - 40,500 LBS
  - 18 FEET LONG
  - 10 FOOT PAYLOAD DIAMETER
- STATUS
  - TITAN (DOD) LAUNCH NOVEMBER 1982
  - STS LAUNCH JANUARY 1983 (STS 6 - TDRS)

NASA-S-75-707

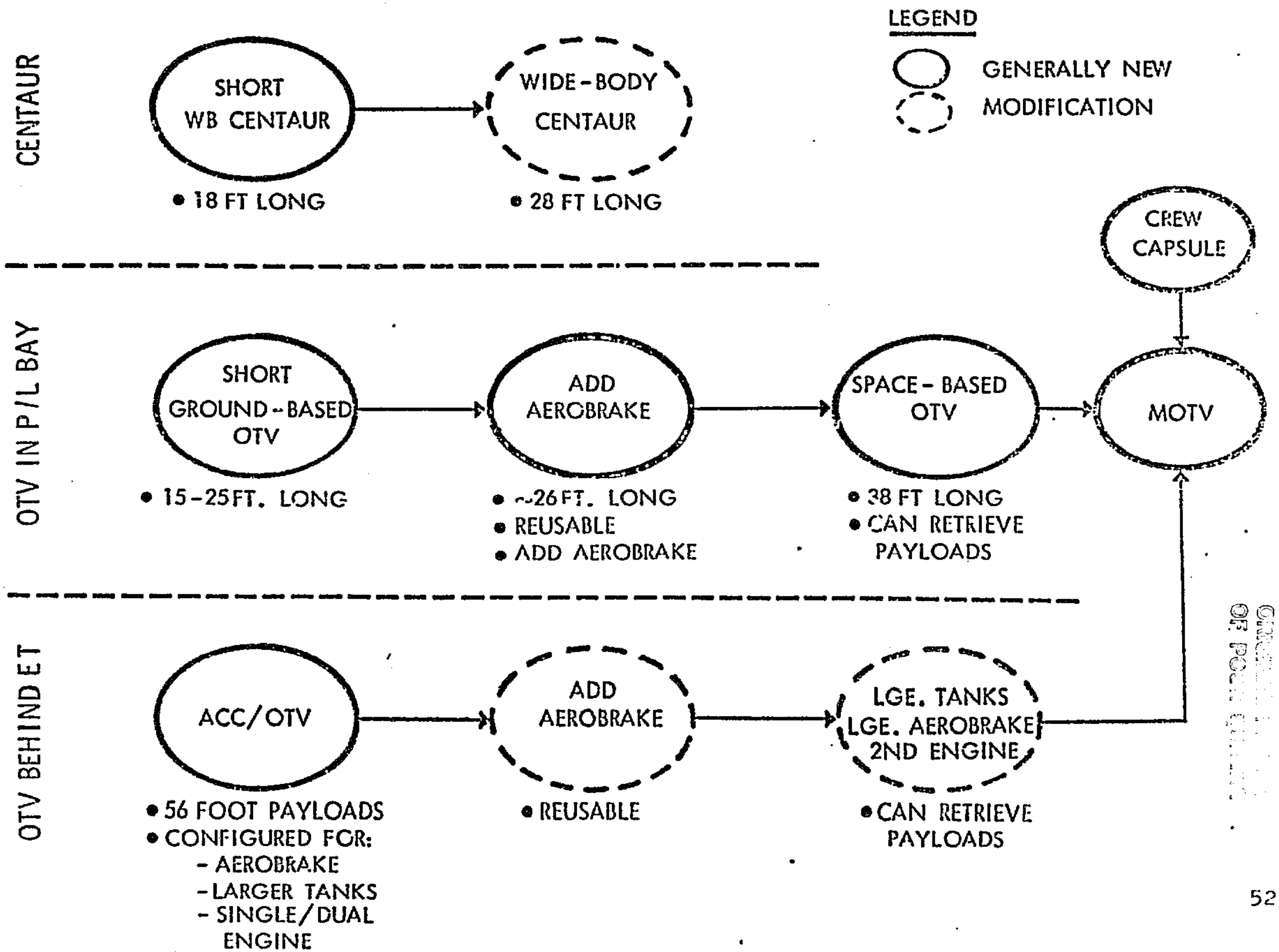
TYPICAL IUS MISSION PAYLOAD DEPLOYMENT



CENTAUR AS AN ELEMENT OF THE STS

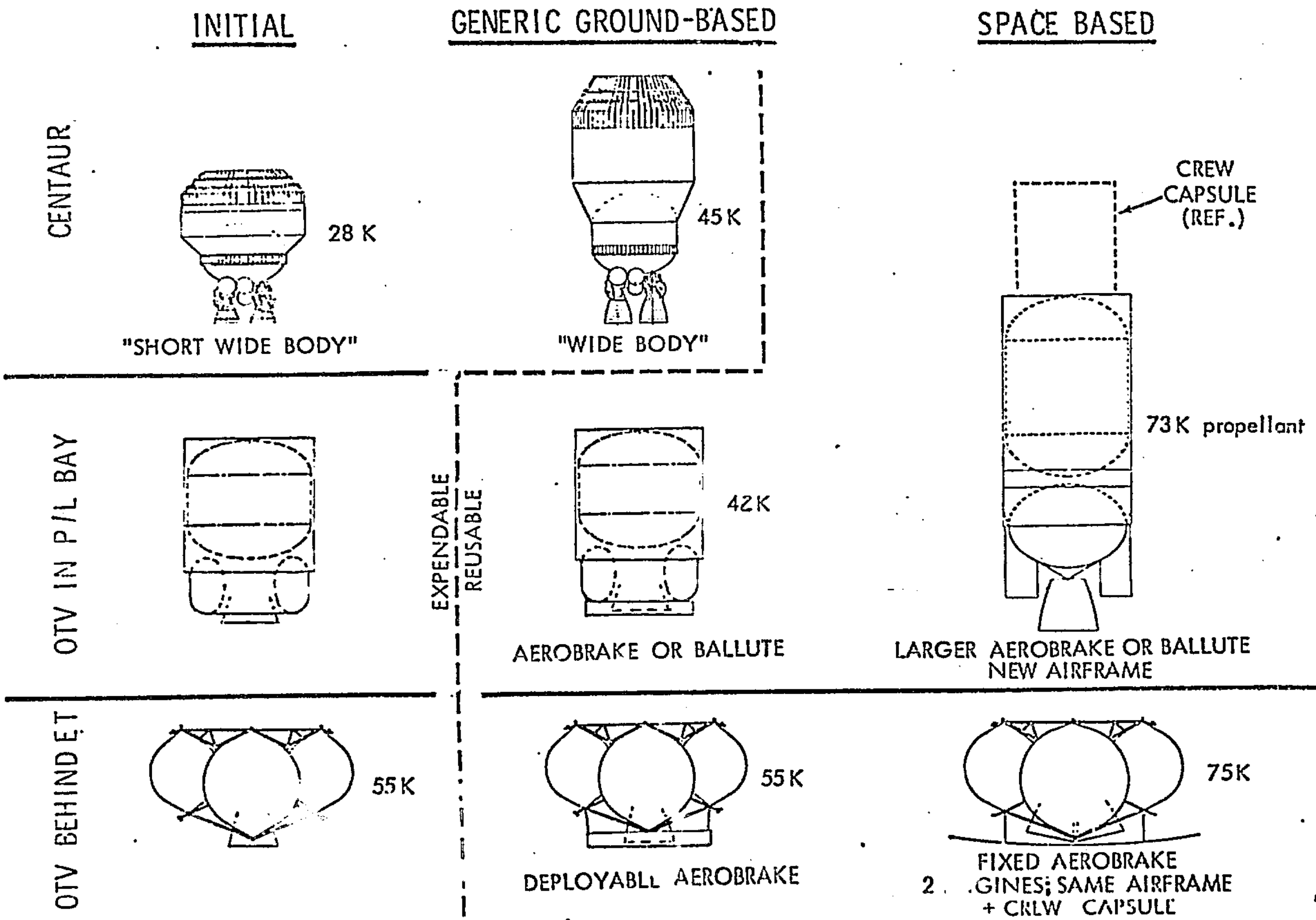
- CENTAUR IS A LEVEL III ELEMENT OF THE STS
  - OPERATIONAL IN THE NATIONAL INVENTORY SINCE 1966
  - MODIFICATIONS FOR OPERATIONS OUT OF THE SHUTTLE ARE INCORPORATED TO PROVIDE SAFETY AT AFFORDABLE COST
- MISSION ASSIGNMENTS
  - GALILEO: LAUNCH APRIL/MAY 1985
  - ISPM: LAUNCH MAY 1986
- OPERATING SYSTEMS
  - CENTAUR: CURRENT SINGLE STRING PLUS ADDED FAILURE TOLERANCE AS REQUIRED FOR SAFETY
  - CISS: TWO-FAILURE TOLERANT
- SAFETY REVIEWS
  - PHASE 1 SHUTTLE PAYLOAD SAFETY REVIEWS COMPLETED
  - ELEMENT SAFETY REVIEWS WILL BE CONDUCTED AS PART OF PDRs AND CDRs

GENERAL EVOLUTION PLAN



GROWTH OPTIONS

ALL AT SAME SCALE



SPACE STATION FLUIDS RESUPPLY AND MANAGEMENT

- ORBITER CAN BE USED TO DELIVER RESUPPLY FLUIDS (PROPELLANT, ETC.) TO THE SPACE STATION SYSTEM
- OPTIONS
  - MODULAR (TANK DELIVERY)
  - PROPELLANT TRANSFER AND STORAGE (SPACE STATION DEPOT)
  - MPS PROPELLANT SCAVENGING OPTIONS
  - OMS PROPELLANT SCAVENGING
- SPACE STATION FLUIDS MANAGEMENT SYSTEM TRADE STUDIES ARE REQUIRED TO DEFINE STS ROLE IN FLUIDS RESUPPLY
- STATUS:
  - FLUID MANAGEMENT TECHNOLOGY EFFORTS BEING FUNDED BY NASA/OAST
  - STS EXPERIMENT IN LATE 1980's

STATUS OF MAJOR STS IMPROVEMENTS

(NOT PRESENTLY PROGRAMMED)

ITEM	STATUS	APPROXIMATE IMPLEMENTATION LEAD TIME, YEARS
• OMS	• PRELIMINARY DESIGN COMPLETE	2 - 3
• LANDING WEIGHT IMPROVEMENT	• PRELIMINARY DESIGN AND ANALYSIS COMPLETE	3
• DOCKING MODULE	• CONCEPTUAL DESIGN ONLY • MECHANISMS TECHNOLOGY WORK IN PROCESS	3 - 5
• VERNIER RCS IMPROVEMENTS	• PRELIMINARY CONCEPT SELECTED	2 - 4
• EXPANDED SEATING ACCOMMODATIONS	• CONCEPTUAL DESIGN COMPLETE • DETAILED DESIGN FOR SEVEN SEATS COMPLETE • SIX CREWMEN ON S/L-1 FLIGHT (9/83)	1 - 2
• STARBOARD RMS	• DESIGN COMPLETE • CONTROL SYSTEM CAN ACCOMMODATE TWO UNITS OPERATED SEQUENTIALLY	1
• 8PSI EMU/SUIT	• TECHNOLOGY DEMONSTRATION 1983	3 - 5

SUMMARY

- MANY OF THE STS IMPROVEMENTS OR MODIFICATIONS NOTED IN THIS PRESENTATION ARE NOT CURRENTLY PROGRAMMED AND ARE THEREFORE SUBJECT TO FUTURE FUNDING LIMITATIONS
- THE STS IS A MATURING SYSTEM THAT WILL DERIVE INCREASING CAPABILITY FOR SUPPORTING THE SPACE STATION SYSTEM THROUGH:
  - EXPERIENCE
  - PROJECTED IMPROVEMENT TO SYSTEMS
  - IMPLEMENTATION OF ADDITIONAL (E.G., SPACE STATION) REQUIREMENTS
- CONTINUING DEFINITION OF THE SPACE STATION SYSTEM WILL EVOLVE ADDITIONAL REQUIREMENTS THAT WILL PERMIT FOCUSING OF STS IMPROVEMENT OPTIONS AND RESOURCES
- MAS STUDIES SHOULD PROVIDE THE BASIS FOR SPACE STATION-RELATED STS IMPROVEMENT REQUIREMENTS

SPACE STATION TECHNOLOGY OPTIONS

RICHARD F. CARLISLE

SEPTEMBER 15, 1982

SPACE STATION TECHNOLOGY STEERING COMMITTEE MEMBERS

COMMITTEE MEMBERS

WALTER B. OLSTAD	(HQ)	CHAIRMAN
DELL P. WILLIAMS	(HQ)	DEPUTY CHAIRMAN
RICHARD F. CARLISLE	(HQ)	EXECUTIVE SECRETARY
CAROLYN KIMBALL	(HQ)	RECORDING SECRETARY
LEONARD HARRIS	(HQ)	
LEE B. HOLCOMB	(HQ)	
MARK B. NOLAN	(HQ)	
PAUL F. HOLLOWAY	(LARC)	
HENRY PLOTKIN	(GSFC)	
ANDREW PICKETT	(KSC)	
ALLEN LOUVIERE	(JSC)	
LAWRENCE ROSS	(LERC)	
WILLIAM HUBER	(MSFC)	
KENNETH C. COON	(JPL)	
JOSEPH SHARP	(ARC)	

SPACE STATION TECHNOLOGY STEERING COMMITTEE WORKING GROUPS

WORKING GROUPS	WORKING GROUP CHAIRMEN	HQ MEMBER
DATA MANAGEMENT	WILLIAM SWINGLE (JSC)	C. FUECHSEL (R)
ENVIRONMENTAL CONTROL & LIFE SUPPORT	WALTER W. GUY (JSC)	J. BREDT (E)
SYSTEMS/OPERATIONS TECHNOLOGY	W. RAY HOOK (LARC)	W. TUMULTY (R)
ATTITUDE, CONTROL, & STABILIZATION	STEPHEN SZIRMAY (JPL)	J. DAHLGREN (R)
POWER	JIMMY MILLER (MSFC)	J. AMBRUS (R)
THERMAL	WILBERT ELLIS (JSC)	W. HUDSON (R)
AUXILIARY PROPULSION	DONALD PETRASH (LERC)	W. HUDSON/F. STEPHENSON (R)
STRUCTURES & MECHANISMS	MICHAEL F. CARD (LARC)	S. VENNERI (R)
COMMUNICATIONS	RICHARD DICKINSON (JPL)	D. SANTARPIA (E)
HUMAN CAPABILITIES	ALAN CHAMBERS (ARC)	A. NICOGOSSIAN (E)

SPACE STATION
TECHNOLOGY STEERING COMMITTEE
GOALS AND OBJECTIVES

GOALS:

PROVIDE BROAD AGENCY GUIDANCE IN THE INITIATION AND IMPLEMENTATION OF TECHNOLOGY DEVELOPMENT PROGRAMS TO SUPPORT AN AGENCY THRUST TO ESTABLISH MANNED PERMANENT OCCUPANCY OF SPACE

OBJECTIVES:

1. ESTABLISH THE DESIRED LEVEL OF TECHNOLOGY TO BE USED IN THE INITIAL DESIGN AND OPERATION OF AN EVOLUTIONARY LONG-LIFE SPACE STATION AND THE LONGER TERM TECHNOLOGY TO BE USED FOR LATER APPLICATION FOR IMPROVED CAPABILITIES. INITIAL TECHNOLOGY SHOULD BE AVAILABLE BY APPROXIMATELY 1986 TO SUPPORT A SPACE STATION LAUNCH AS EARLY AS 1990
2. ASSESS THE LEVEL OF TECHNOLOGY FORECAST TO BE AVAILABLE FROM THAT PORTION OF THE CURRENT BASE R&T PROGRAM WHICH WILL BE APPLICABLE TO A SPACE STATION
3. PLAN, RECOMMEND, AND MONITOR A PROGRAM TO MOVE THE CURRENT TECHNOLOGY TO THE LEVEL STATED IN NUMBER ONE ABOVE
4. IDENTIFY, EVALUATE, AND RECOMMEND OPPORTUNITIES TO UTILIZE THE SPACE STATION AS AN R&T FACILITY

SPACE STATION TECHNOLOGY WORKING GROUP

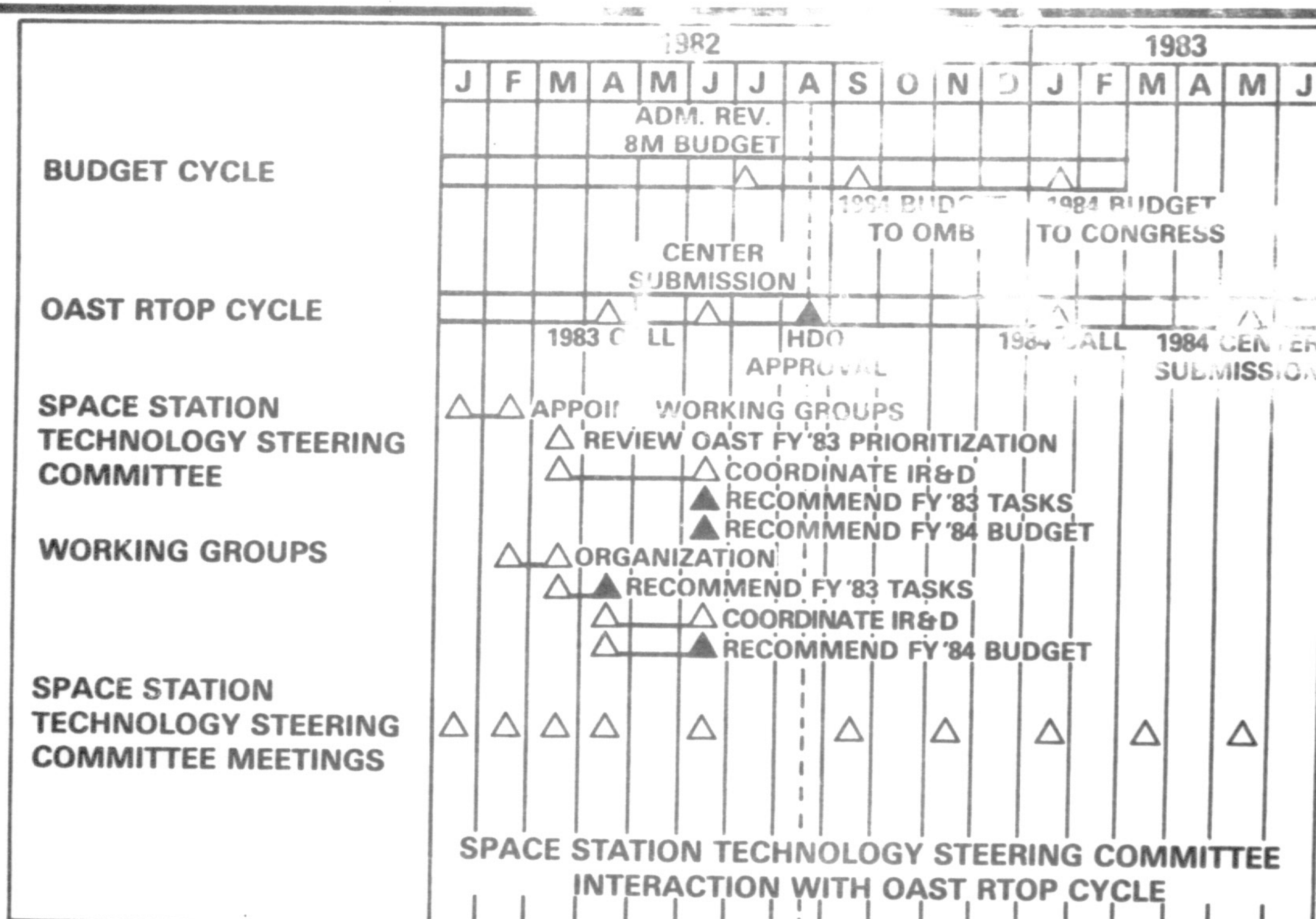
INITIAL GROUND RULES

REVISION A, APRIL 1982

- o WILL BE IN LEO
- *o WILL BE SUPPORTED BY THE SHUTTLE, INITIALLY ON 90 DAY CYCLES
- *o SHALL HAVE A DESIGN GOAL FOR INDEFINITE LIFE THROUGH ON-ORBIT MAINTENANCE
- o SHALL HAVE MODULAR-EVOLUTIONARY DESIGN THAT PERMITS GROWTH AND ACCEPTS NEW TECHNOLOGY
- o LIFE-CYCLE COST (DEVELOPMENT, OPERATION, MAINTENANCE, UTILIZATION) IS A TECHNOLOGY DRIVER
- o INITIAL PLANNING ASSUMES A PHASE C/D START BY OR BEFORE FY 1986 TO SUPPORT A FLIGHT AS EARLY AS 1990
- o INCLUDE TECHNOLOGY TO SUPPORT MISSION OBJECTIVES BUT NOT THE TECHNOLOGY TO DEVELOP PAYLOADS
- o INCLUDE TECHNOLOGY TO INTERFACE WITH SPACE TRANSPORTATION SYSTEMS BUT NOT TECHNOLOGY TO DEVELOP NEW TRANSPORTATION VEHICLES
- o COMMUNICATIONS SHALL BE COMPATIBLE WITH TDRSS/TDAS, FREE-FLYERS, OTV'S AND SHUTTLE
- o SHALL PROVIDE FOR NON-HAZARDOUS, PLANNED REENTRY
- o SHALL BE A MANNED SYSTEM, THOUGH NOT NECESSARILY IN THE FIRST PHASE

*CHANGE BY REVISION A, APRIL 1982

SPACE STATION SCHEDULE OF ACTIVITY



EARLY CONCLUSIONS

- A SPACE STATION COMPARABLE TO SALYUTS 6 AND 7 COULD BE BUILT WITH CURRENT (SKYLAB) TECHNOLOGY
- AFFORDABLE GROWTH POTENTIAL WOULD NOT BE AVAILABLE
- LIFE CYCLE COSTS WOULD NOT BE CONSIDERED
- INDEFINITE LIFE THROUGH ON-ORBIT MAINTENANCE WOULD NOT BE COST EFFECTIVE
- COMMUNICATIONS WOULD NOT BE COMPATIBLE WITH CURRENT SYSTEMS

BALANCED TECHNOLOGY PROGRAM DEFINED BY THEMES

- THEMES DEFINE TECHNOLOGY THRUSTS THAT WILL ENABLE FUTURE PROGRAM NEEDS
- THEMES WILL BE ACCOMPLISHED BY THE DEVELOPMENT OF INDIVIDUAL DISCIPLINE TASKS OR THE INTEGRATION OF SEVERAL DISCIPLINE TASKS
- TASKS WILL BE PLANNED, SCHEDULED, FUNDED, AND EXECUTED BY DISCIPLINE
- SOME TASKS SYNERGISTIC TO MULTIPLE THEMES

TECHNOLOGY THEMES

- HUMAN CAPABILITIES IN SPACE
- SYSTEM AND SUB SYSTEM AUTOMATION
- ADVANCED INFORMATION SYSTEM
- ENERGY MANAGEMENT
- EVOLUTIONARY ATTITUDE CONTROL AND STABILIZATION
- HYDROGEN-OXYGEN FLUID SYSTEMS

HUMAN CAPABILITIES CHARACTERISTICS

- CLOSED LOOP REGENERATIVE LIFE SUPPORT
- IVA & HABITABILITY
- MAN/MACHINE FUNCTION ALLOCATION
- HUMAN INTERFACE TO INTELLIGENT SYSTEMS
- EVA SUIT, MOBILITY AIDS, TOOLS
- CREW & WORK STATION
- DIRECT, SUPERVISORY & AUTOMATIC (AUTONOMOUS) CONTROL OF TELEOPERATOR & ROBOTIC SYSTEMS

HUMAN CAPABILITY IN SPACE BENEFITS

- PHASED UTILIZATION OF HUMAN CAPABILITIES IN INITIAL AND EVOLUTIONARY SPACE STATION
- PROVIDES EVOLUTIONARY TRANSITION FROM MANUAL TO AUTOMATED OPERATION
- PROVIDES COMPATIBILITY OF MAN WITH AUTOMATED SYSTEMS AND MAN-MACHINE ENVIRONMENT
- OPTIMIZES HUMAN ROLE AND PRODUCTIVITY FOR ON-BOARD AND REMOTE OPERATIONS
- REDUCES COST OF CONSUMABLES VIA CLOSURE OF LIFE SUPPORT LOOP
- ENSURES SPACE STATION HABITABILITY FOR LONG DURATION OCCUPANCY

AUTOMATION CHARACTERISTICS

- AUTONOMOUS SYSTEM
- HIERARCHICAL CONTROL
- FAULT TOLERANT
- AUTOMATED SUB-SYSTEM CONTROL & MANAGEMENT
- SELF DIAGNOSIS/REPAIR
- HUMAN I/F TO INTELLIGENT SYSTEMS
- HIGH SPEED/CAPACITY DATA SYSTEM

AUTOMATION BENEFITS

- THIS TECHNOLOGY HAS HIGH LEVERAGE ON LIFE-CYCLE COSTS
- CAN ELIMINATE NEED FOR VAST MAJORITY OF GROUND-BASED FLIGHT CONTROLLERS
- CAN MINIMIZE MAINTENANCE, REPAIR AND UPGRADE COSTS
- UTILIZES MAN-IN-THE-LOOP IN SUPERVISORY CAPACITY
- EXTENDS HUMAN CAPABILITY TO REMOTE OPERATIONS

ADVANCED INFORMATION SYSTEM CHARACTERISTICS

- FIBER OPTIC BUS & COMPONENTS
- FAULT TOLERANT COMPUTER
- OPTICAL DISC STORAGE
- MAGNETIC BUBBLE DEVICES
- INTEGRATED SOFTWARE DEVELOPMENT & MANAGEMENT
- ADAPTIVE DATA NETWORKING
- AUTOMATIC SELF TEST
- FAULT DETECTION, ISOLATION & CORRECTION

ADVANCED INFORMATION SYSTEM BENEFITS

- ROBUST ON BOARD COMPUTATIONAL CAPABILITY AND ADAPTIVE NETWORK ARCHITECTURE ALLOWS EVOLUTIONARY GROWTH
- HIGH SPEED, HIGH CAPACITY PROCESSING AND HIGH SPEED BUSS SERVES VARIETY OF ENVISIONED APPLICATIONS
- HIGH RELIABILITY VIA FAULT TOLERANT HARDWARE AND SOFTWARE
- PROVIDES CAPABILITY FOR INTEGRATED AVIONICS SYSTEM FOR ON-BOARD CONTROL AND MANAGEMENT OF SPACE STATION FUNCTIONS, PAYLOADS, AND REMOTE OPERATIONS
- HIGH LEVERAGE ON LIFE CYCLE COST VIA REDUCED GROUND SUPPORT REQUIREMENT
- GREAT POTENTIAL FOR SECONDARY APPLICATION ACROSS BROAD RANGE OF PUBLIC AND COMMERCIAL ENDEAVORS

ENERGY MANAGEMENT CHARACTERISTICS

- o HIGH CAPACITY ENERGY STORAGE
- o IMPROVED PERFORMANCE SOLAR ARRAYS
- o FUEL CELL ELECTROLYSIS
- o AUTOMATED POWER SUB-SYSTEM
- o HIGH VOLTAGE/POWER COMPONENTS
- o BULK POWER TRANSFER
- o INTEGRATED THERMAL UTILITY/THERMAL BUS
- o MAINTAINABLE/REPLACEABLE FLUID RADIATOR

ENERGY MANAGEMENT BENEFITS

- OPTIMIZATION OF POWER & THERMAL SYSTEM INTEGRATION
- MINIMUM AREA ARRAY & RADIATOR REDUCES DRAG
- UTILIZATION OF WASTE HEAT SAVES ENERGY
- AUTOMATION REDUCES OPERATION COST AND IMPROVES PERFORMANCE
- HIGHLY INTERACTIVE WITH ALL OTHER SUBSYSTEMS, PAYLOADS, & OPERATIONS
- HIGH VOLTAGE/POWER SYSTEM ADVANTAGE
- NiH_2 BATTERY AVAILABLE FOR INITIAL STATION

EVOLUTIONARY ATTITUDE CONTROL AND STABILIZATION CHARACTERISTICS

- PREDICTIVE METHODS FOR LARGE SPACECRAFT RESPONSE
- INTEGRATED ANALYSIS METHODS (STRUCTURAL/THERMAL/CONTROLS)
- ADVANCED MATERIALS & DEVICES FOR ACTIVE/PASSIVE DAMPING OPTIMIZATION
- ADVANCED G&C COMPONENTS
- LARGE MOMENTUM MANAGEMENT DEVICES
- RENDEZVOUS, DOCKING, BERTHING SYSTEMS
- ADVANCED MECHANISMS

EVOLUTIONARY ATTITUDE CONTROL AND STABILIZATION BENEFITS

- INTEGRATED ANALYTICAL TECHNOLOGIES FOR PREDICTING DYNAMIC/CONTROL RESPONSE OF LOW FREQUENCY, HIGHLY NON-LINEAR SYSTEMS

- ADVANCED SENSORS AND ALGORITHMS FOR IN-SITU SYSTEMS IDENTIFICATION

- HIGH PERFORMANCE, ROBUST ACTUATORS FOR CONTROL OF STRUCTURAL TIME VARYING CHARACTERISTICS

- MODULAR CONTROL FOR MULTI-FUNCTIONAL OPERATION OF DYNAMICALLY COUPLED MULTI-BODY SYSTEMS

- ADAPTIVE CONTROL FOR SYSTEMS RECONFIGURATION AND EVOLUTIONARY GROWTH

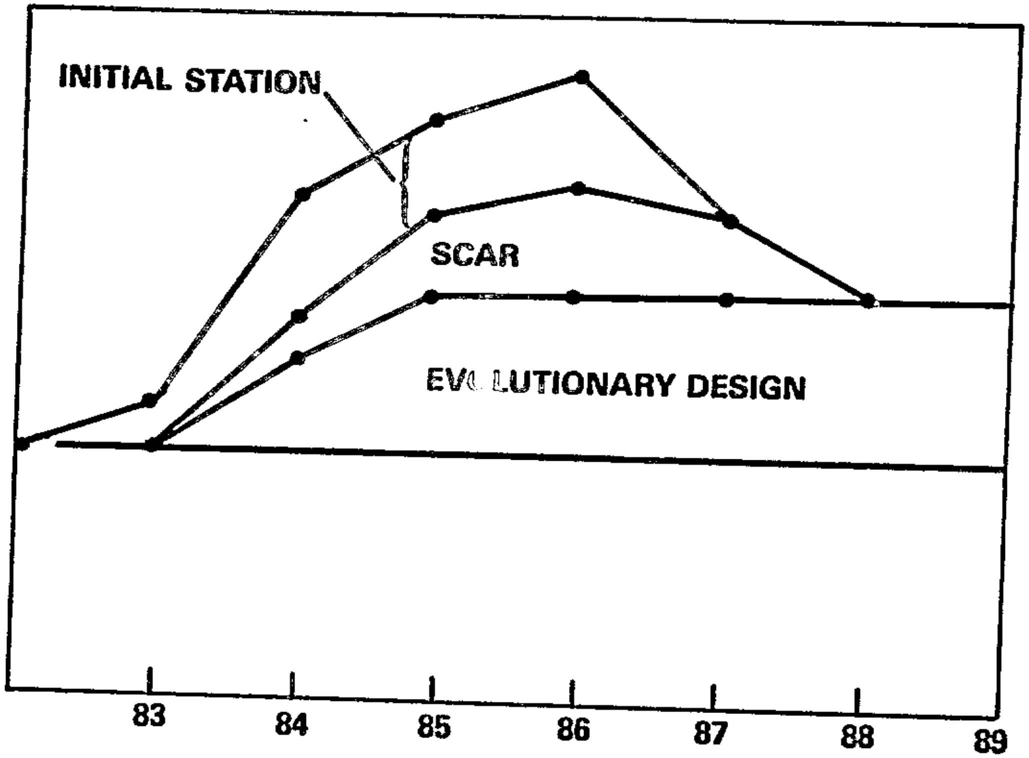
H_2-O_2 SYSTEMS — CHARACTERISTICS

- LOW THRUST GASEOUS H/O APS COMPONENT
- CRYOGENIC FLUID RESUPPLY: TECHNOLOGY PROCESSOR TO CFME
- CRYOGENIC FLUID MANAGEMENT: SYSTEM & COMPONENT TECHNOLOGY FOR ACQUISITION, SUPPLY, STORAGE, DISTRIBUTION & MANAGEMENT, INCLUDING GAGING, LEAK DETECTION, LEAK PREVENTION, INSULATION, PUMPS, VALVES, SEALS, CONNECTORS, ETC.
- CREW & LIFE SUPPORT/ENERGY MANAGEMENT INTEGRATED SYSTEM DEVELOPMENT
- ATTITUDE CONTROL (APS)/ENERGY/CREW & LIFE SUPPORT SYSTEMS DEVELOPMENT

HYDROGEN-OXYGEN FLUID SYSTEMS BENEFITS

- CAN BE USED FOR PROPELLANTS, FUEL CELLS, LIFE SUPPORT, AND COOLANTS
- POTENTIAL SIMPLIFICATIONS IN OPERATIONS, MAINTENANCE AND RESUPPLY
- FLUIDS CAN BE SCAVENGED FROM EXTERNAL TANKS

SPACE STATION TECHNOLOGY



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OAST

BALANCED TECHNOLOGY PROGRAM

- ACCELERATE TECHNOLOGY READINESS
- ELEVATE LEVEL OF TECHNOLOGY READINESS
- INITIATE LONG-TERM TASKS
- PROVIDE ADDITIONAL OPTIONS
- SCAR INITIAL MODULE
- PROVIDE INPUT TO ADVANCED DEVELOPMENT

SUMMARY

- TECHNOLOGY READINESS FOR INITIAL STATION DRIVES SPEND PLAN
- EVOLUTIONARY REQUIREMENTS IMPACT ON INITIAL STATION DESIGN
- TECHNOLOGY PROVIDES OPTIONS TO PROGRAM
- UP FRONT TECHNOLOGY MONEY IS HIGH LEVERAGE
  - FUELS ADVANCED DEVELOPMENT PROGRAM
  - ENHANCES STATION CAPABILITY AND UTILITY
  - ALLOWS EVOLUTIONARY GROWTH IN PERFORMANCE
  - LOWERS LIFE CYCLE COST
  - REDUCES RISK TO PROJECT COST AND SCHEDULE

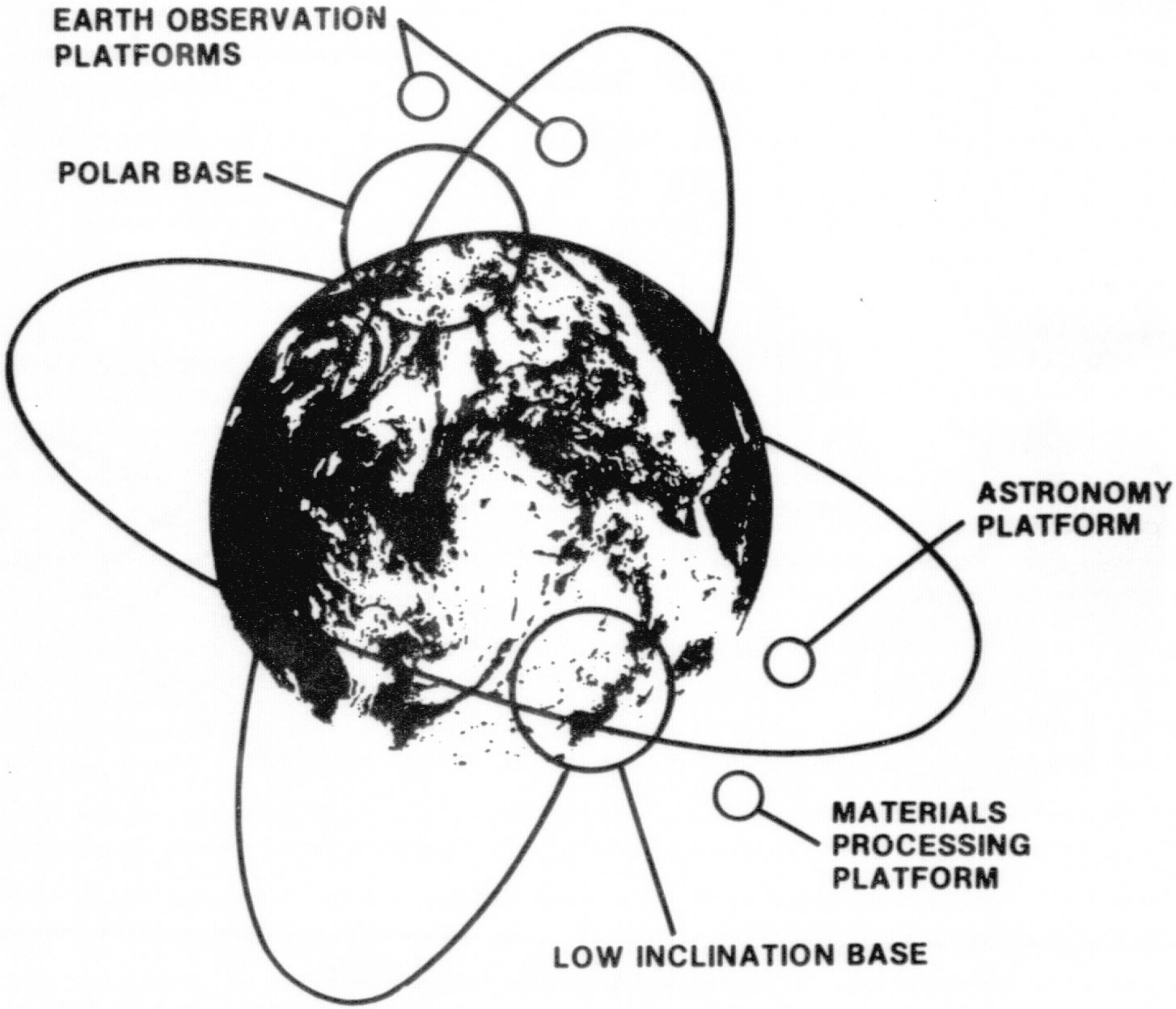
CONCEPTUAL ARCHITECTURES FOR A SPACE STATION

DANIEL H. HERMAN

DIRECTOR

SPACE STATION CONCEPT DEVELOPMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



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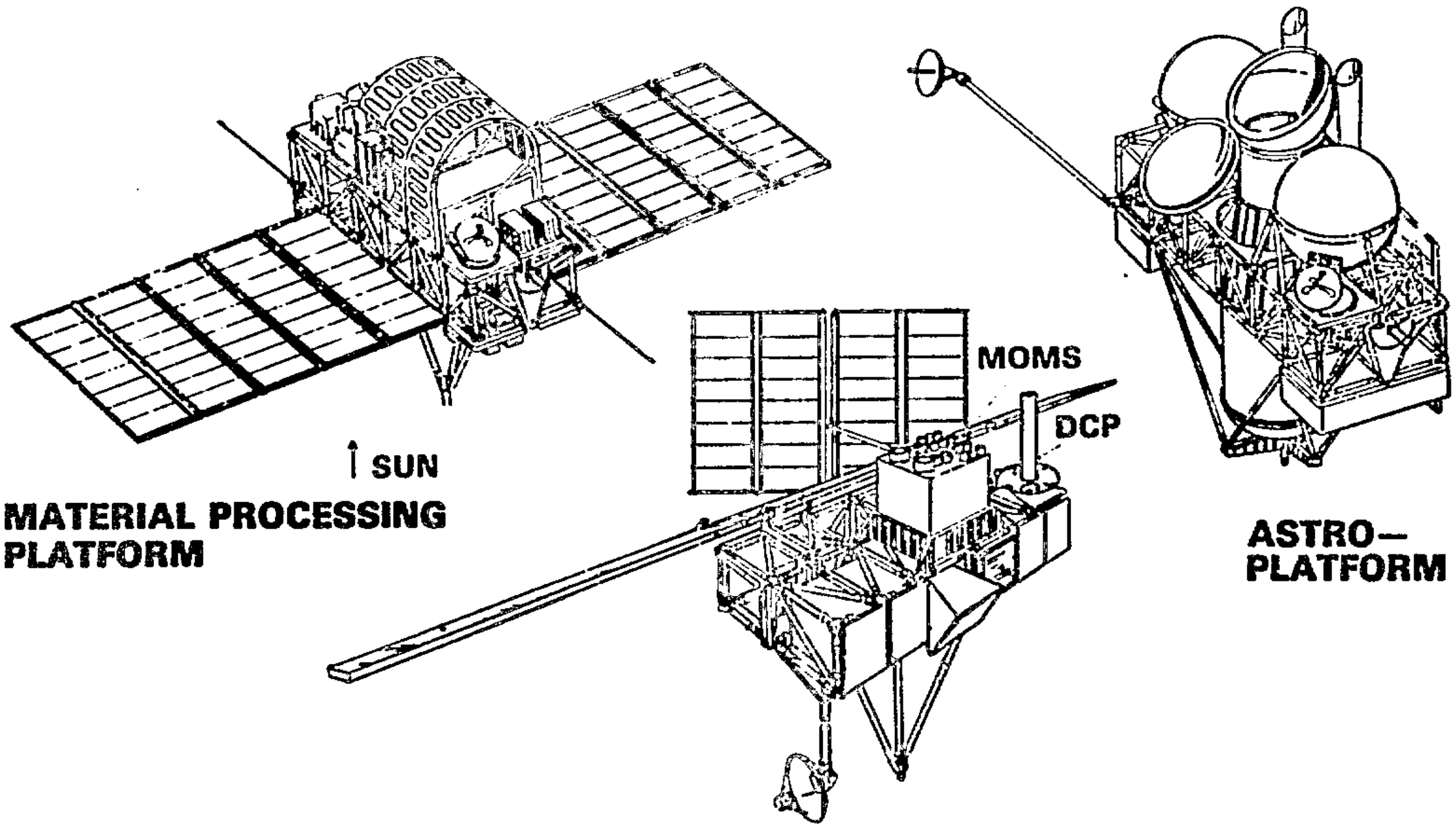
OPERATIONAL DEDICATED PLATFORMS
FOR ASTRONOMY, MATERIAL PROCESSING AND EARTH OBSERVATION



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4-20-82

ELEMENTS OF THE SPACE-BASED INFRASTRUCTURE

Ivan Bekey
Director, Advanced Planning
Office of Space Flight
NASA Headquarters

Contractor Orientation Meetings
Space Station Needs, Attributes and Architectural Options
September 14 & 15, 1982
Washington, D.C.

M2153

OVERALL GOAL

"ESTABLISH PERMANENT PRESENCE IN SPACE"

- INFRASTRUCTURE OF ELEMENTS
- MANNED AND UNMANNED COMPONENTS
  - IN LOW ORBIT BY 1990
  - MANNED IN GEO BY 2000

REQUIRED FUNCTIONS

- AGGREGATION OF PAYLOADS
- MANEUVERING OF SATELLITES
- LOW-COST TRANSFER TO GEO
- REMOTE SATELLITE SERVICING/UPGRADING
- PROPELLANT STORAGE IN ORBIT
- ON-ORBIT ASSEMBLY/CHECKOUT

REQUIRED ELEMENTS

TRANSPORTATION	ORBITAL TRANSFER VEHICLES "LOCAL" MANEUVERING VEHICLES
ORBITAL SERVICES	DOCKING/GRAPPLING/HANDLING MODULE CHANGEOUT MECHANISMS
UNMANNED PLATFORMS	FREE-FLYERS AND TETHERED LEO AND GEO
MANNED FACILITIES	LEO SPACE STATION GEO SORTIE HANGAR CREW CAPSULE FOR OTV

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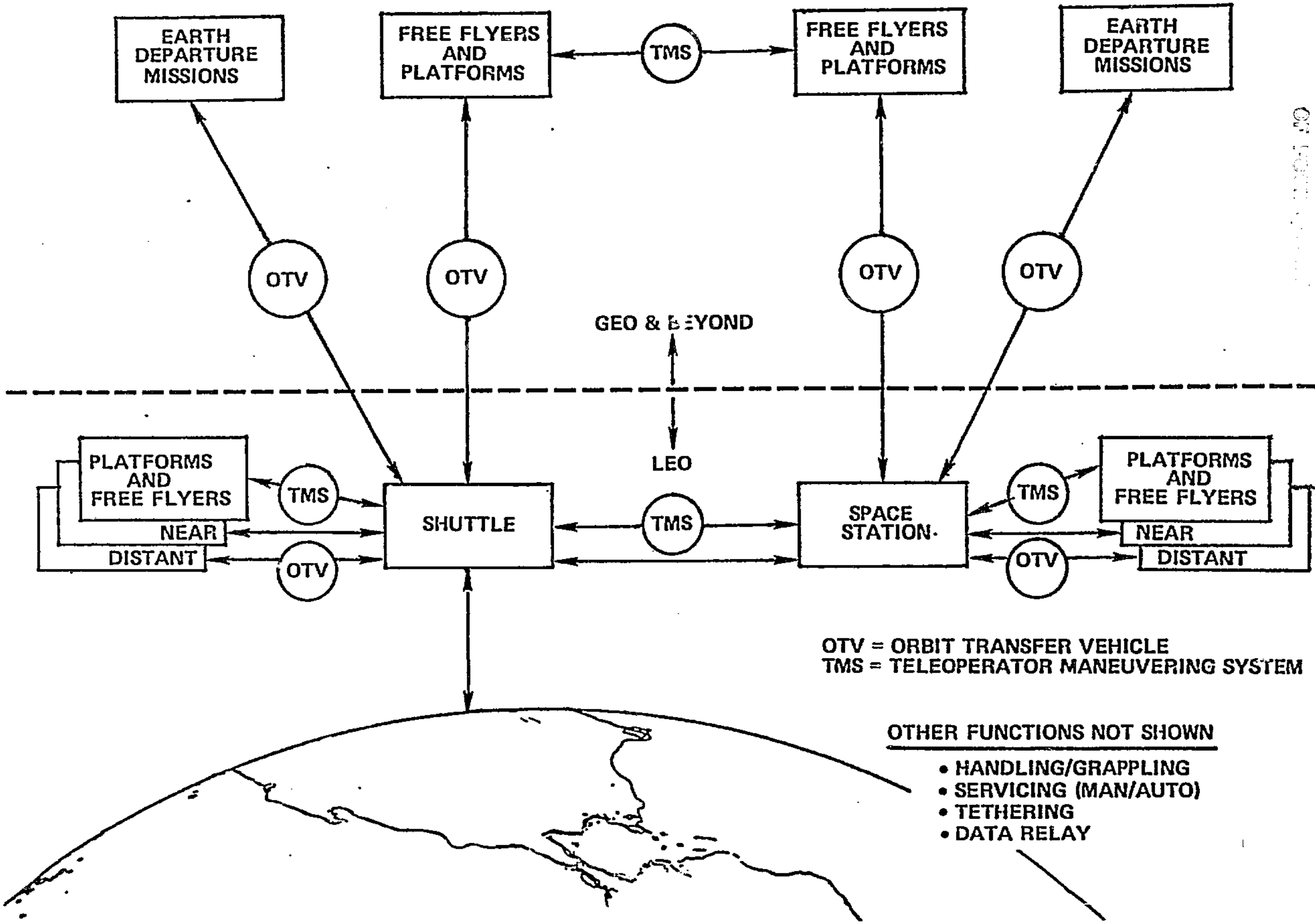
ELEMENTS OF SPACE INFRASTRUCTURE



OTV = ORBIT TRANSFER VEHICLE
TMS = TELEOPERATOR MANEUVERING SYSTEM

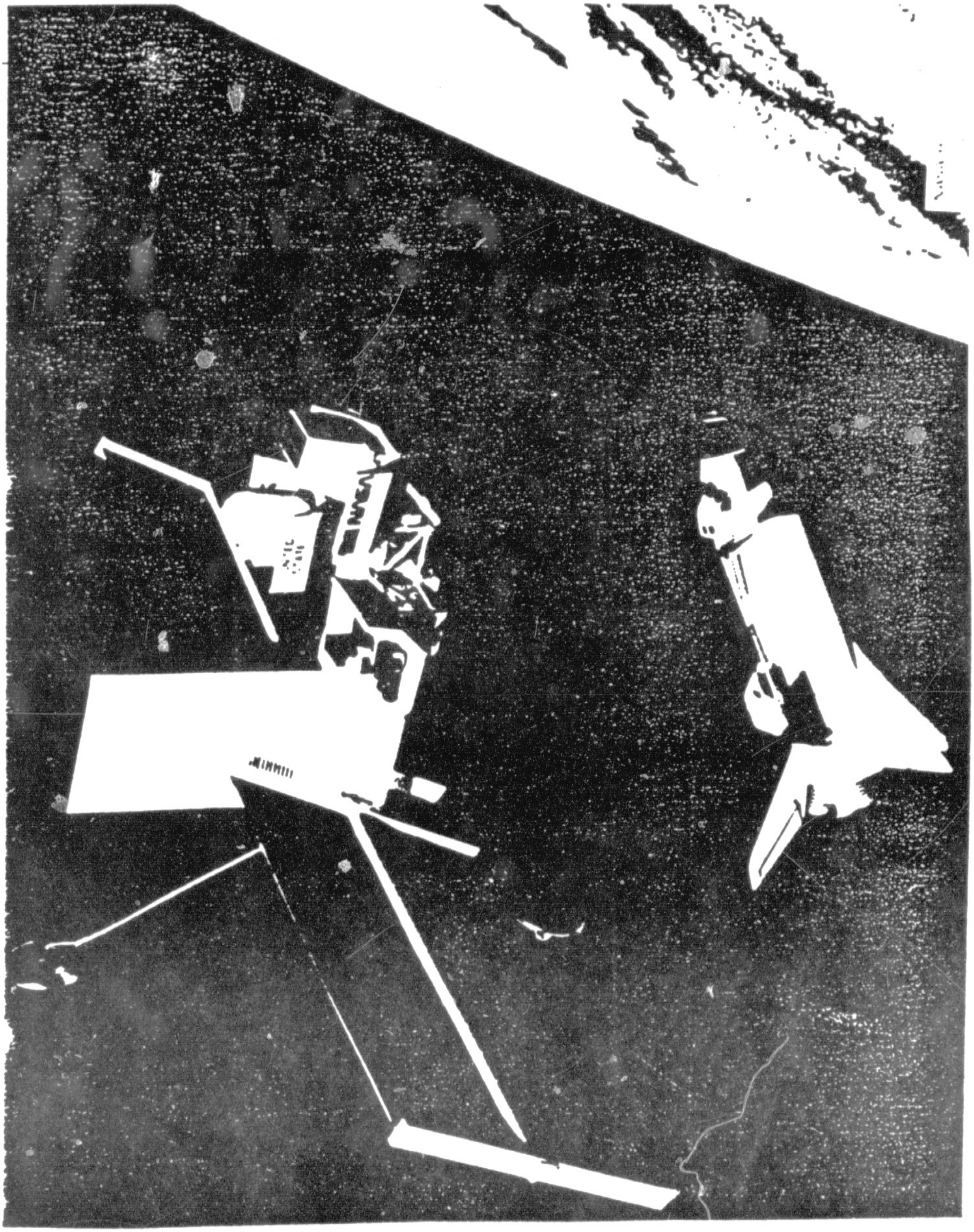
OTHER FUNCTIONS NOT SHOWN

- HANDLING/GRAPPLING
- SERVICING (MAN/AUTO)
- TETHERING
- DATA RELAY

M2064

ELEMENTS OF SPACE INFRASTRUCTURE

	MANNED PERMANENT	UNMANNED PERMANENT	FREE FLYER/EXPENDABLE
GEO FACILITIES	SORTIE MANNED	GEO PLATFORM	FREE FLYERS; SOLAR SYSTEM EXPLORATION VEHICLES
LEO FACILITIES	SPACE STATION	LEO SPACE PLATFORM	FREE FLYERS
ADVANCED TRANSPORTATION	SHUTTLE	STORABLE TELEOPERATED MANEUVER SYSTEM	CRYOGENIC ORBIT TRANSFER VEHICLE
ORBITAL SERVICES	DOCKING, GRAPPLING, HANDLING	ASSEMBLY/ CONTROL LARGE STRUCTURE	MODULE CHANGEOUT MECHANISMS



CANDIDATE PLATFORM PAYLOADS

MISSION	PORT A	PORT B	PORT C
87-2	UV ASTRONOMY (OSS-3)	ELECTROPHORESIS (EOS)	COSMIC RAYS (CRN)
88-1	IR ASTRONOMY (IRT)	ELECTROPHORESIS RESUPPLY (EOS)	X-RAY ASTRONOMY (OSS-2)
88-2	SOLAR OPTICAL TELESCOPE (SOT)	EARTH RADAR (SAR/OWDS/ALS)	ACTIVE PLASMA EXPS. (SEPAC/WISP)
89-1	SHUTTLE IR TELESCOPE (SIRTF)	MATERIALS PROCESSING	RADIO ASTRONOMY (VLBI)
89-2	UV ASTRONOMY (STARLAB)	ENVIRONMENTAL OBS. (LIDAR)	COSMIC RAYS (TRIC)
90-1	ADVANCED SOLAR OBSERVATORY	MATERIALS PROCESSING	SOLAR-TERRESTRIAL OBSERVATORY
90-2	SHUTTLE IR TELESCOPE (SIRTF)	EARTH RADAR (SAR/OWDS/ALS)	X-RAY ASTRONOMY (LAMAR)

- SPACELAB DERIVATIVES
- JOINT ENDEAVOR
- NEW DEVELOPMENTS

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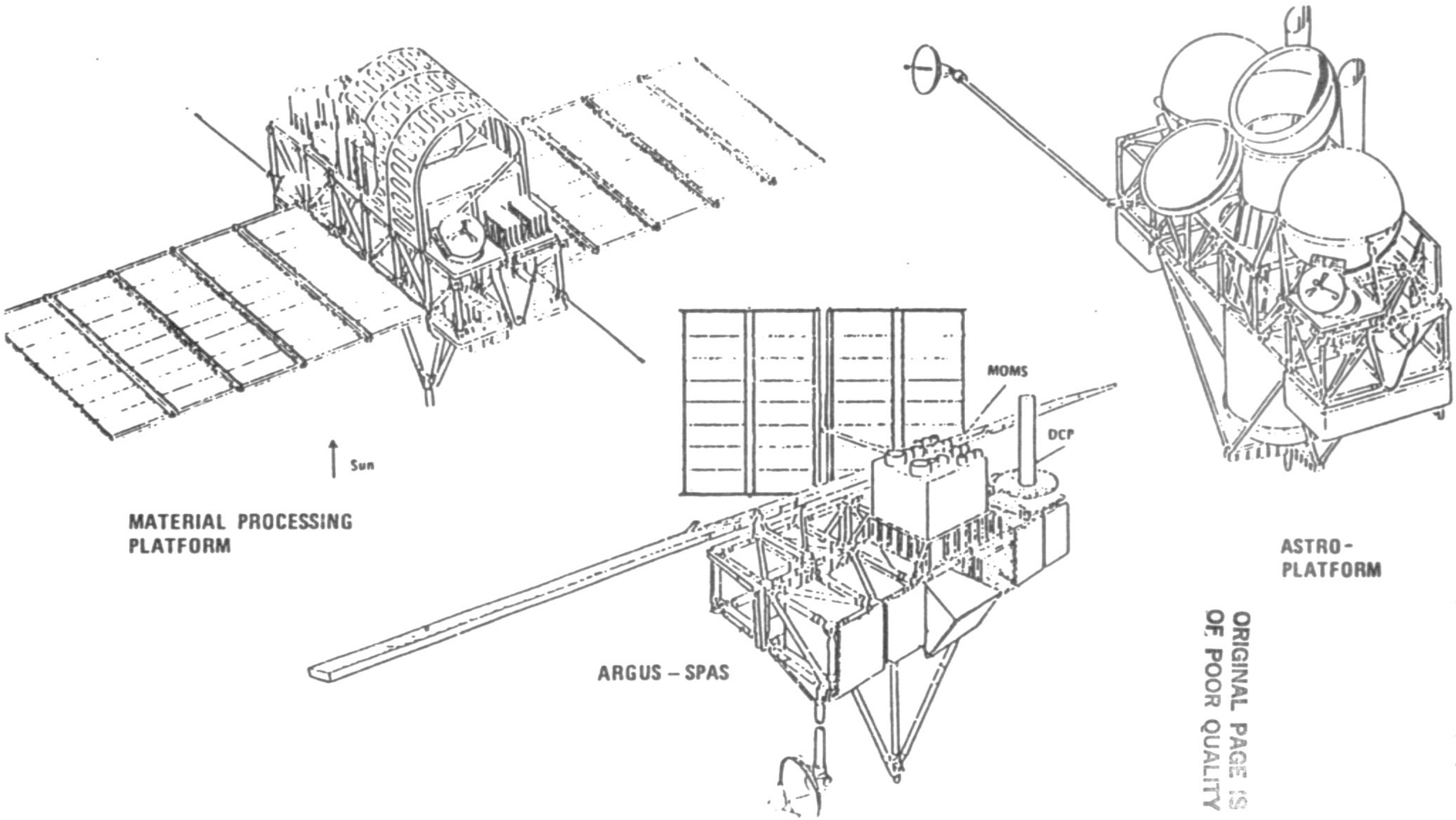
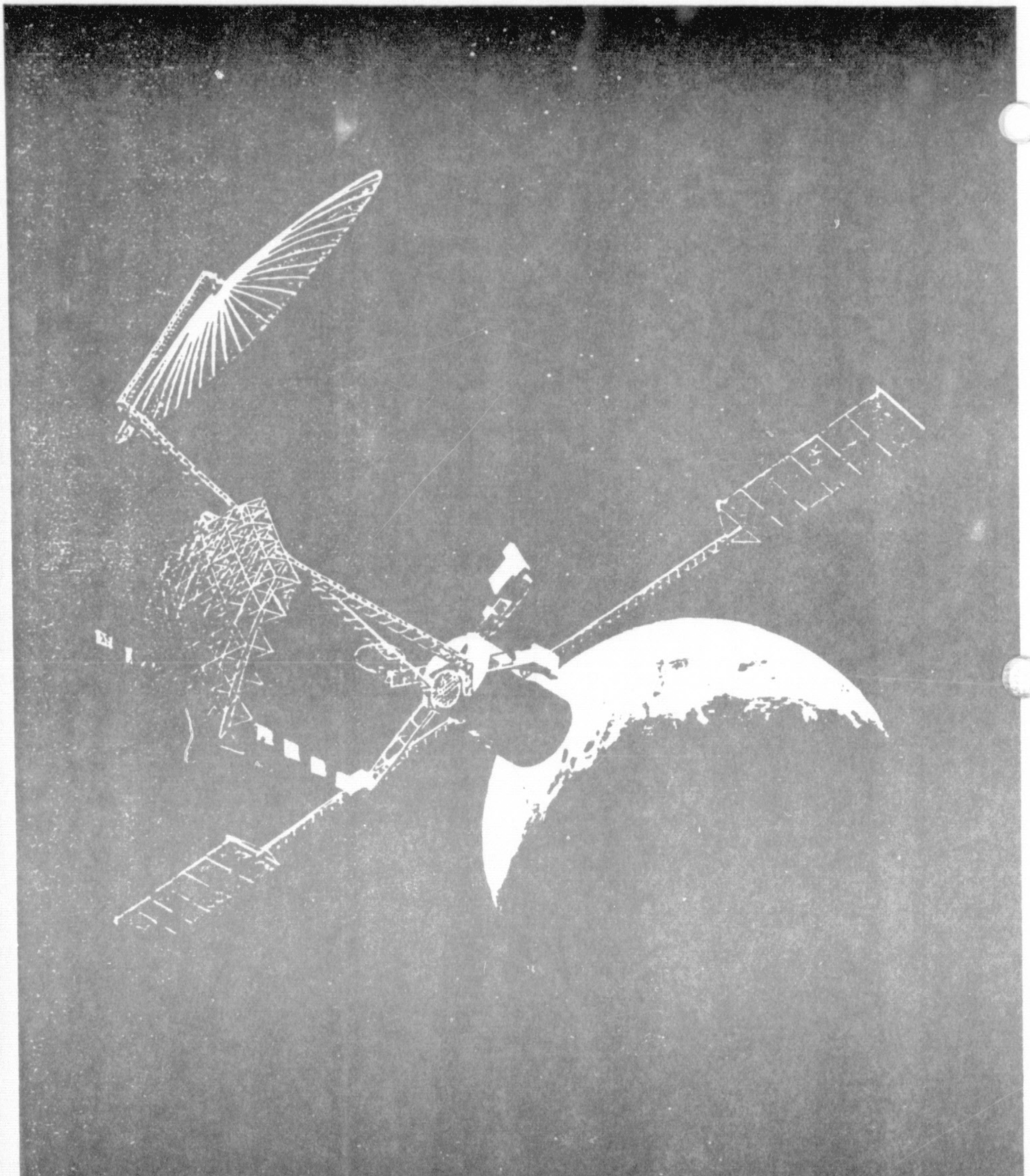
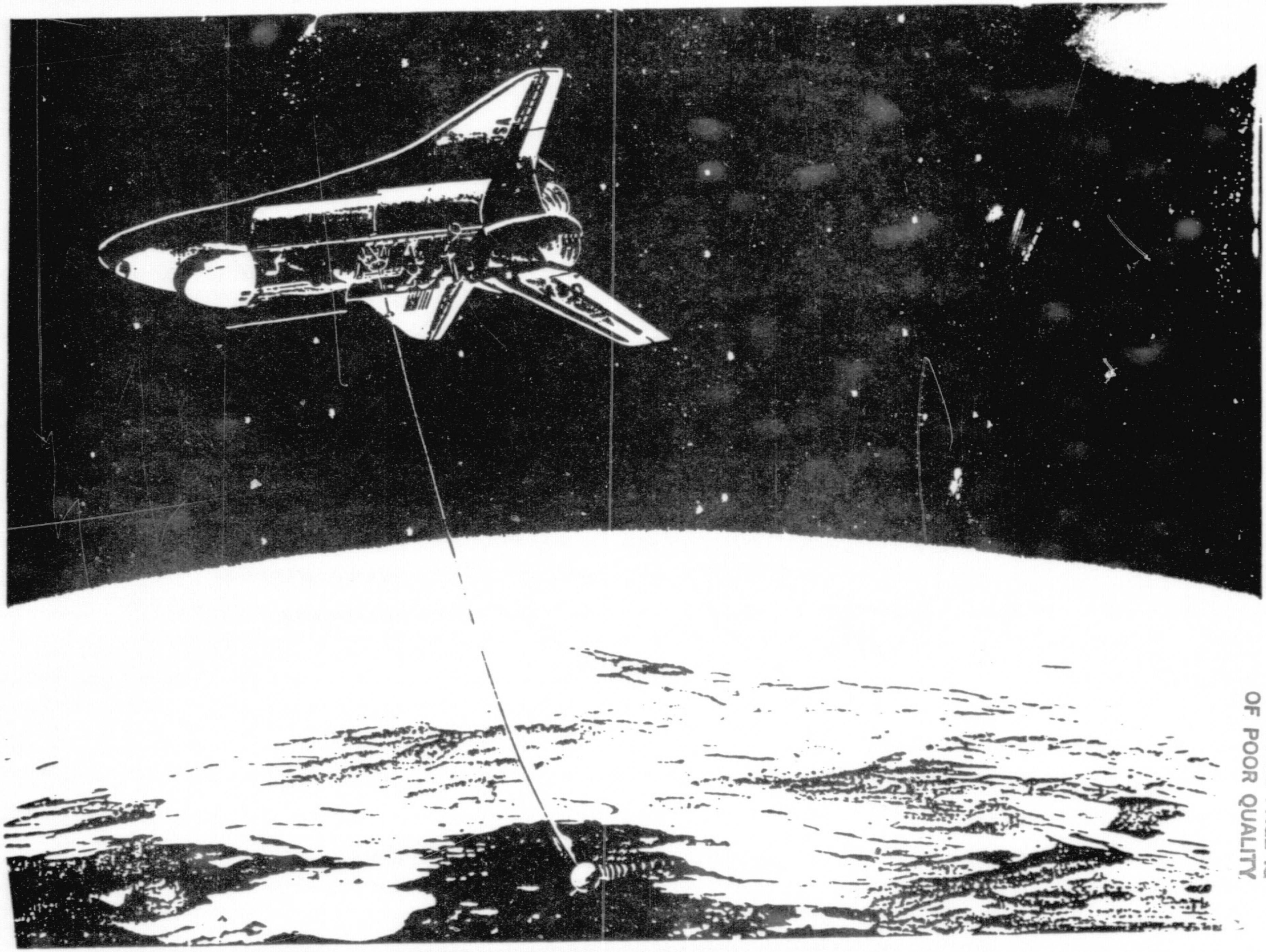
OPERATIONAL DEDICATED PLATFORMS

for Astronomy, Material Processing and Earth Observation

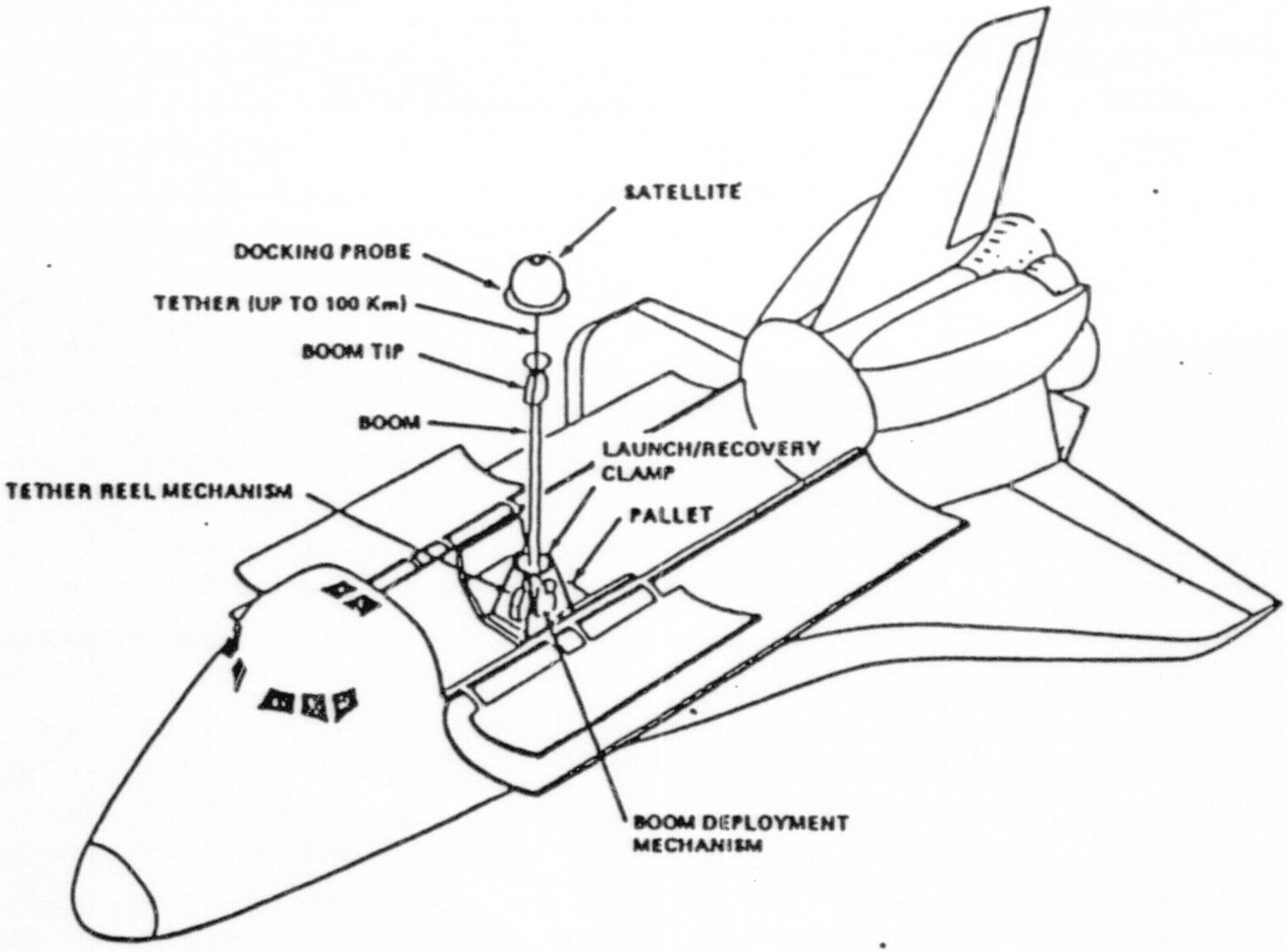




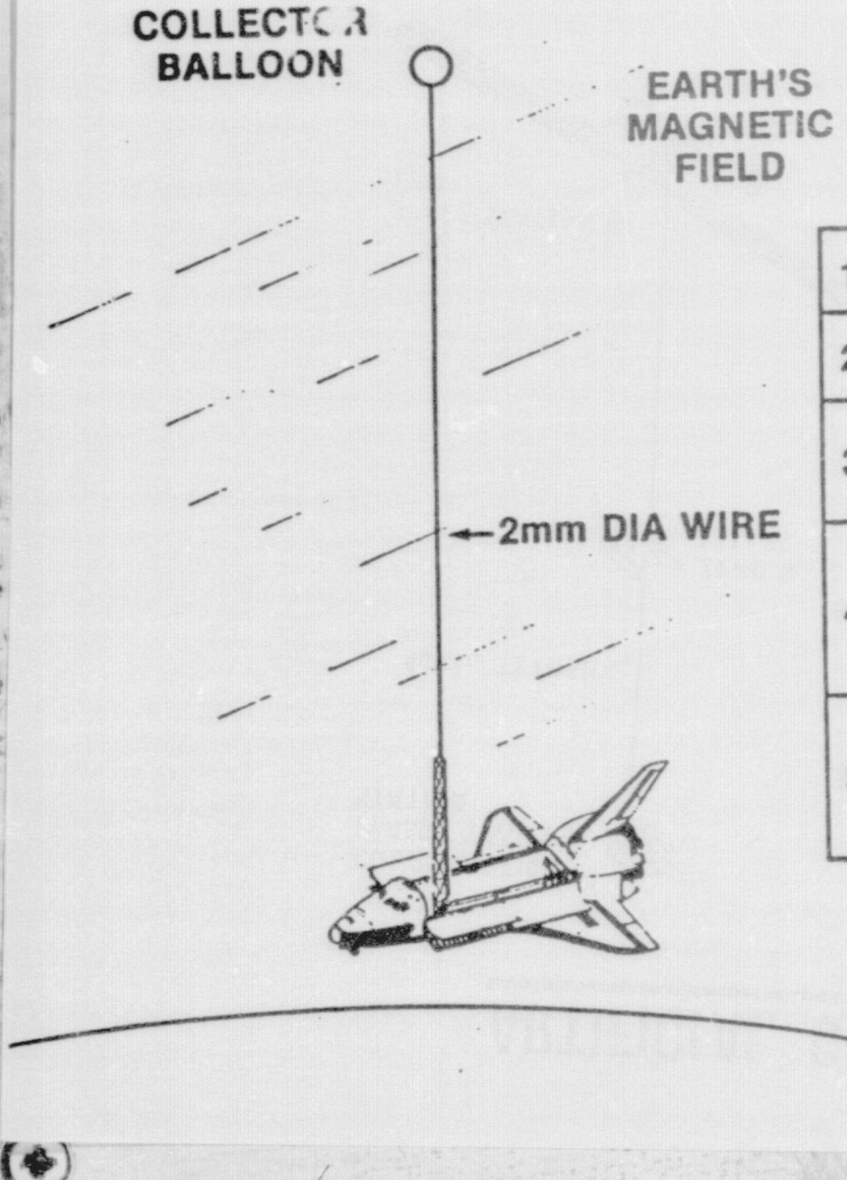
Shuttle/Tethered Satellite System



SHUTTLE/TETHERED SATELLITE SYSTEM

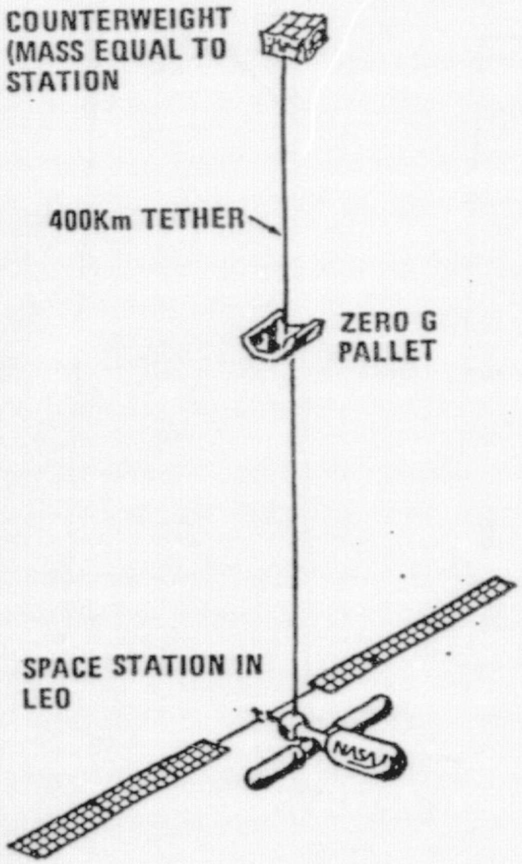


POWER SOURCE FOR SHUTTLE SPACE STATION

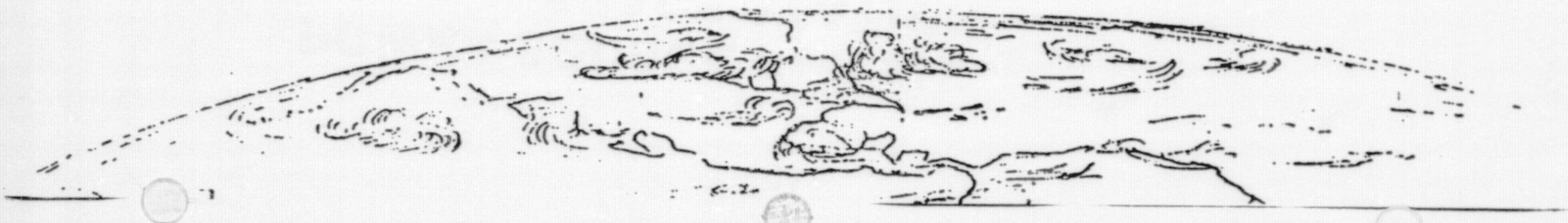


		TETHER LENGTH		
		A. 20km	B. 50km	C. 100km
1.	CURRENT, AMPS	3a	5a	5a
2.	VOLTAGE	3.2kv	7.4kv	14.7kv
3.	NET POWER TO PAYLOADS	8kw	33kw	70kw
4.	ELECTRODYNAMIC DECELERATING FORCE	0.3 lb	1 lb	1.8 lb
5.	TIME FOR ORBITER ALTITUDE DECREASE = 20 n.mi.	21 DAYS	7 DAYS	4 DAYS

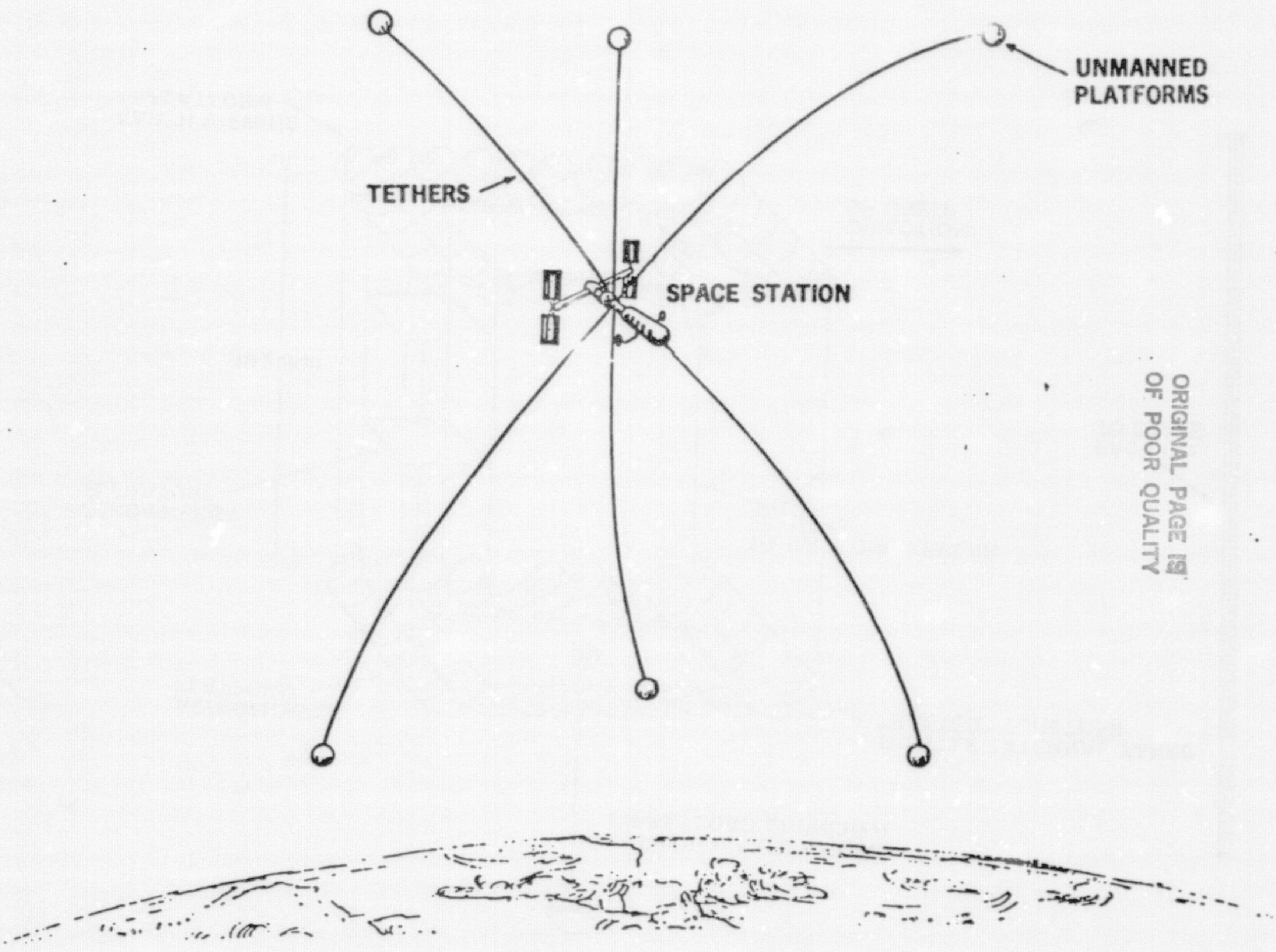
ARTIFICIAL GRAVITY FOR SPACE STATION

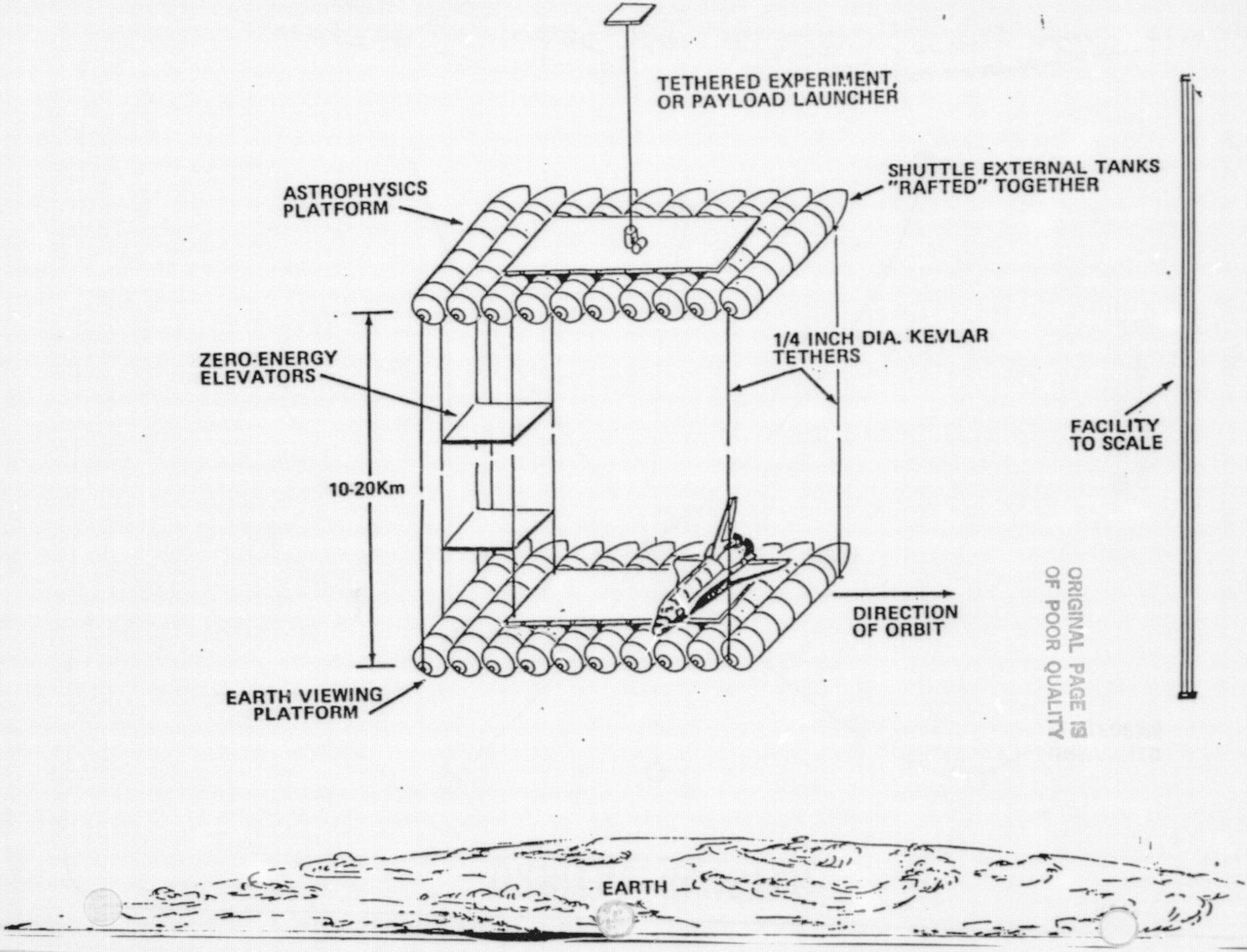


- GRAVITY IN STATION - $1/10$ G
- HABITATS AND WORKSHOPS DESIGNED AND OPERATED AS ON EARTH
- DRAG MAKEUP NEEDED ONLY HALF AS OFTEN
- ATTITUDE CONTROL PROPELLANT SAVINGS
- VARIABLE GRAVITY (0 - 0.1g) CAN BE OBTAINED FOR EXPERIMENTS ON 4 PALLET

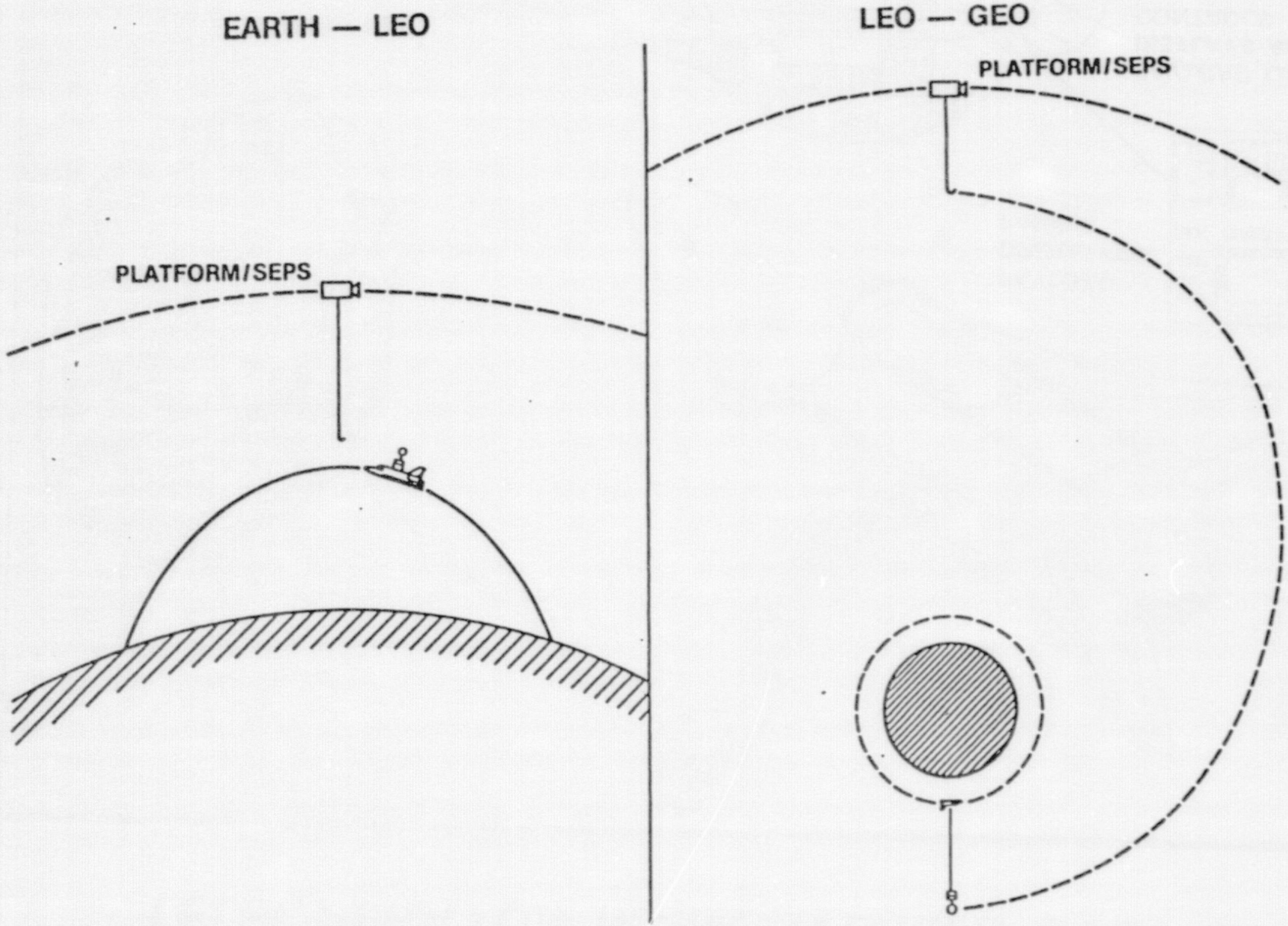


ORBITAL CLUSTER

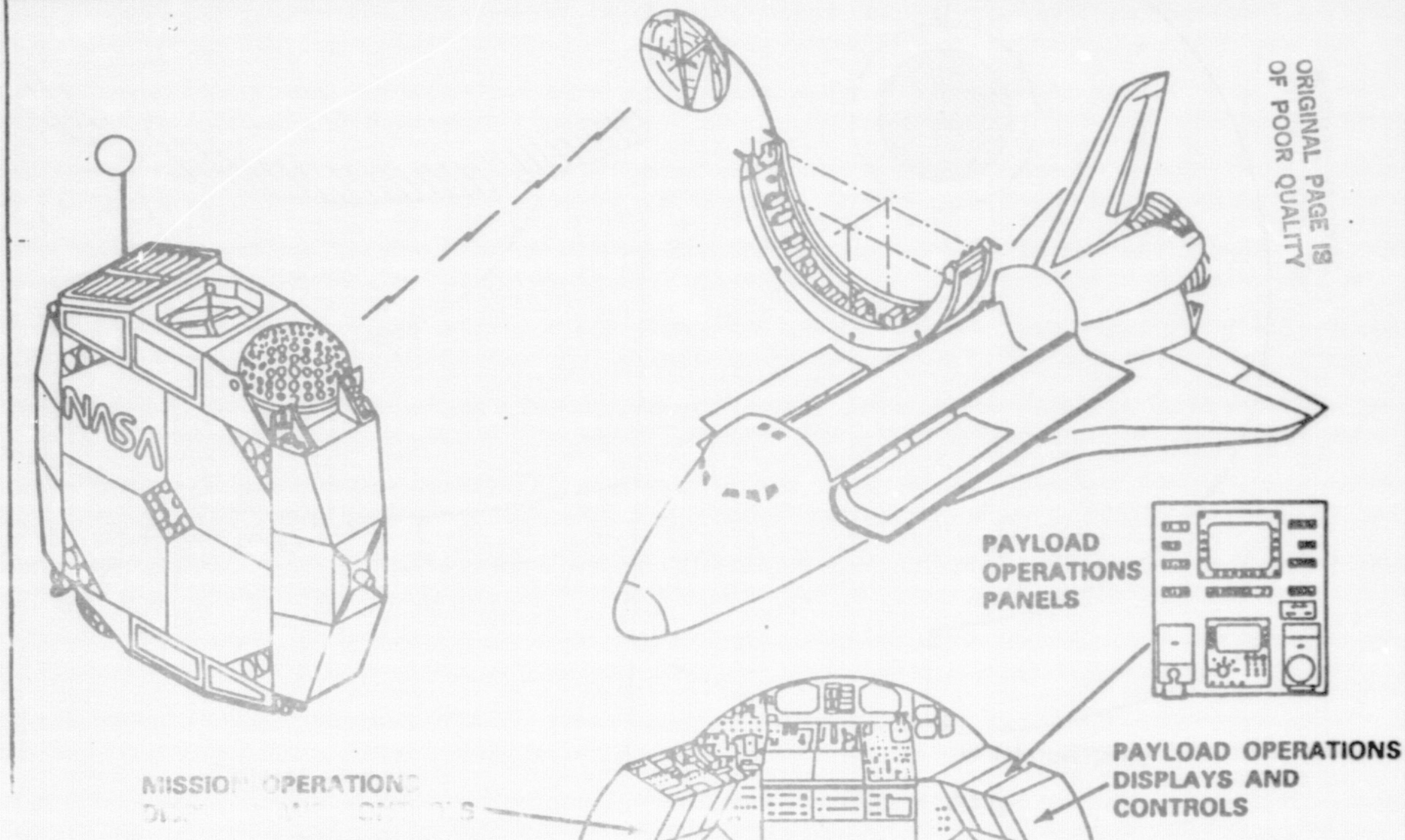



TETHERED EXPERIMENT,
OR PAYLOAD LAUNCHER
SHUTTLE EXTERNAL TANKS
"RAFTED" TOGETHER
ASTROPHYSICS
PLATFORM
1/4 INCH DIA. KEVLAR
TETHERS
ZERO-ENERGY
ELEVATORS
FACILITY
TO SCALE
10-20Km
DIRECTION
OF ORBIT
EARTH VIEWING
PLATFORM
EARTH

TETHER-ASSISTED ORBIT TRANSFER



TELEOPERATOR MANEUVERING SYSTEM



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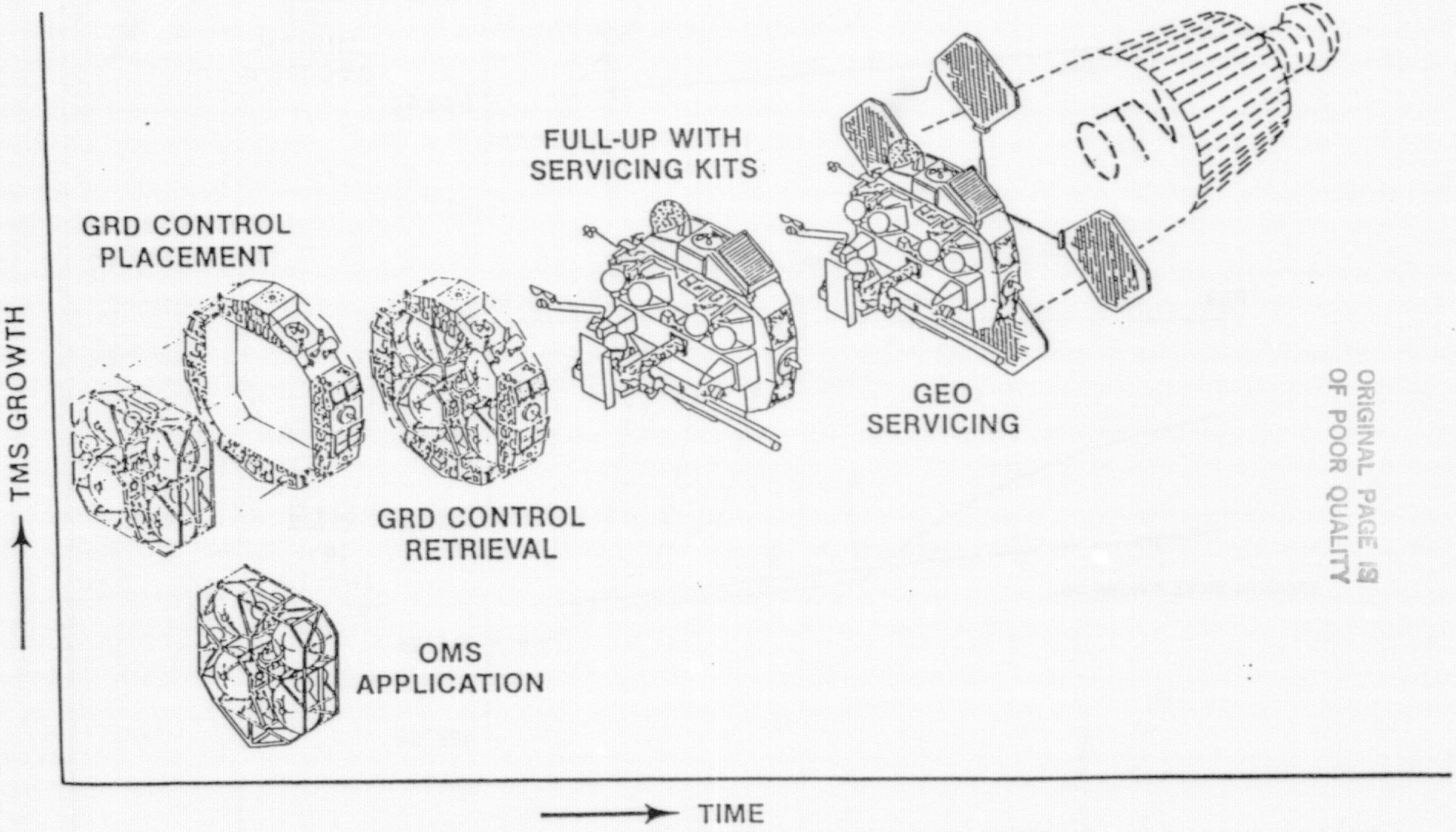
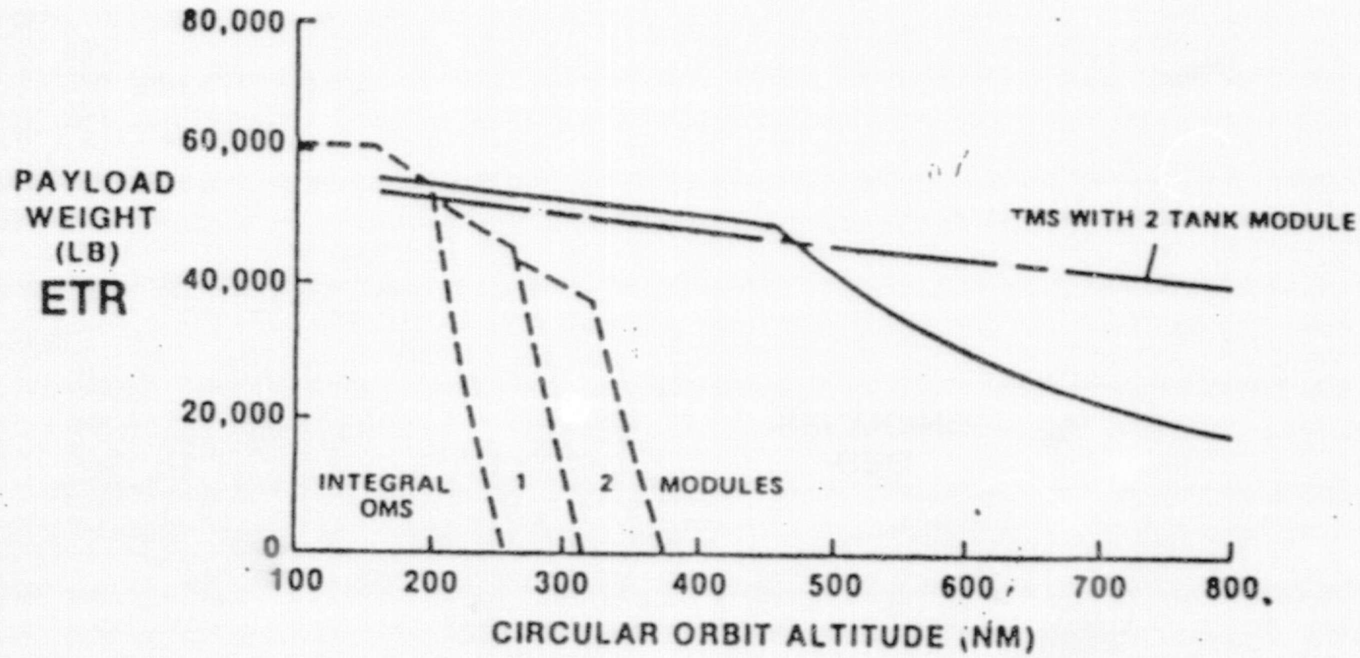
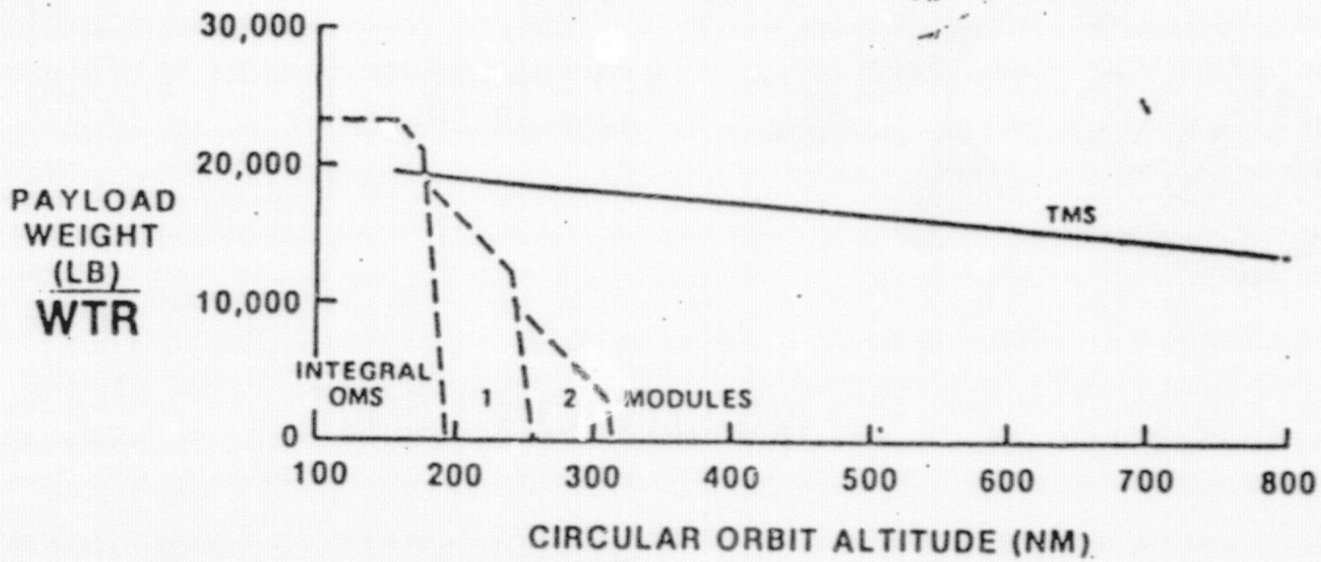
TMS EVOLUTION



STS PERFORMANCE ENHANCEMENT USING TMS





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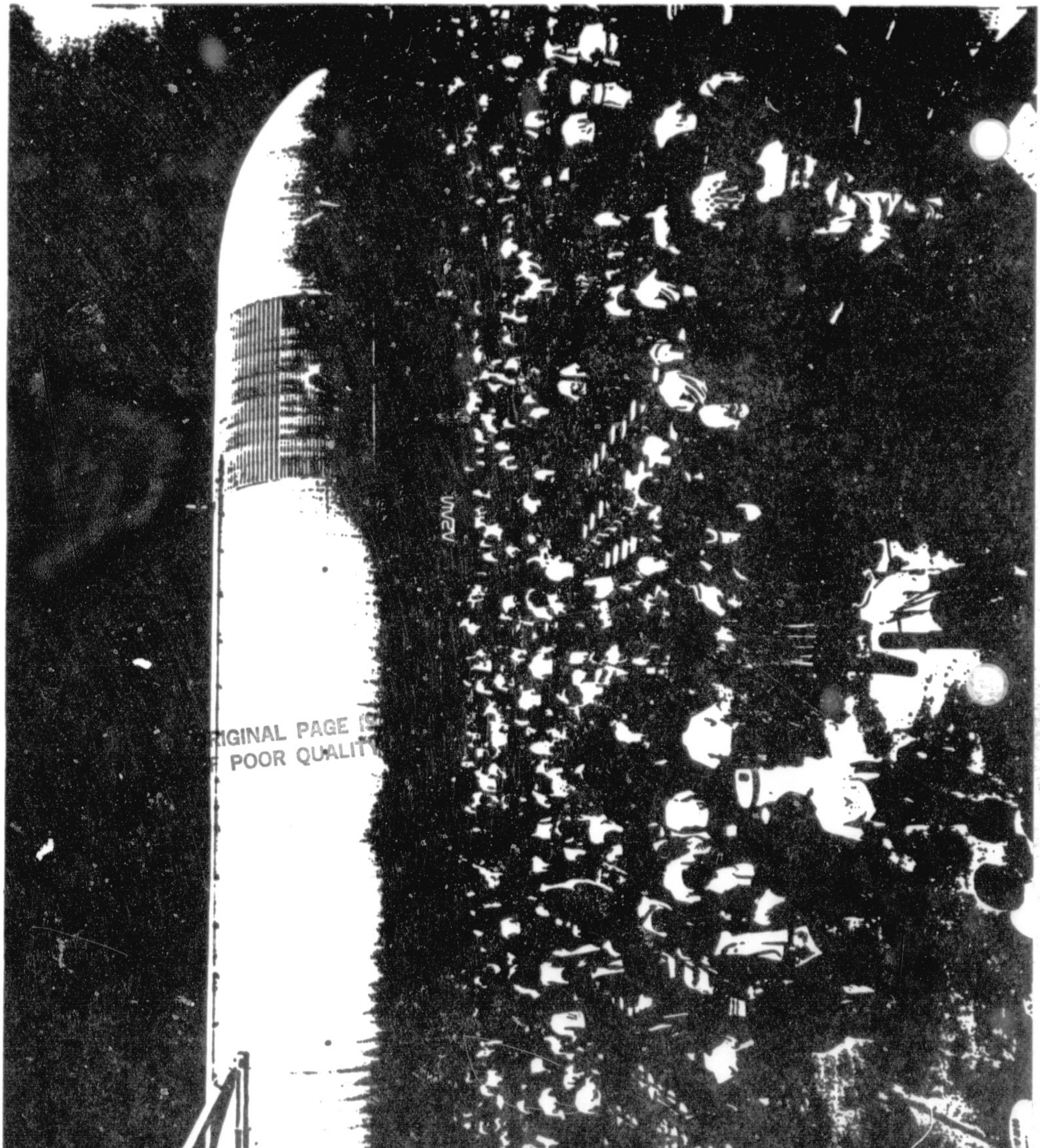
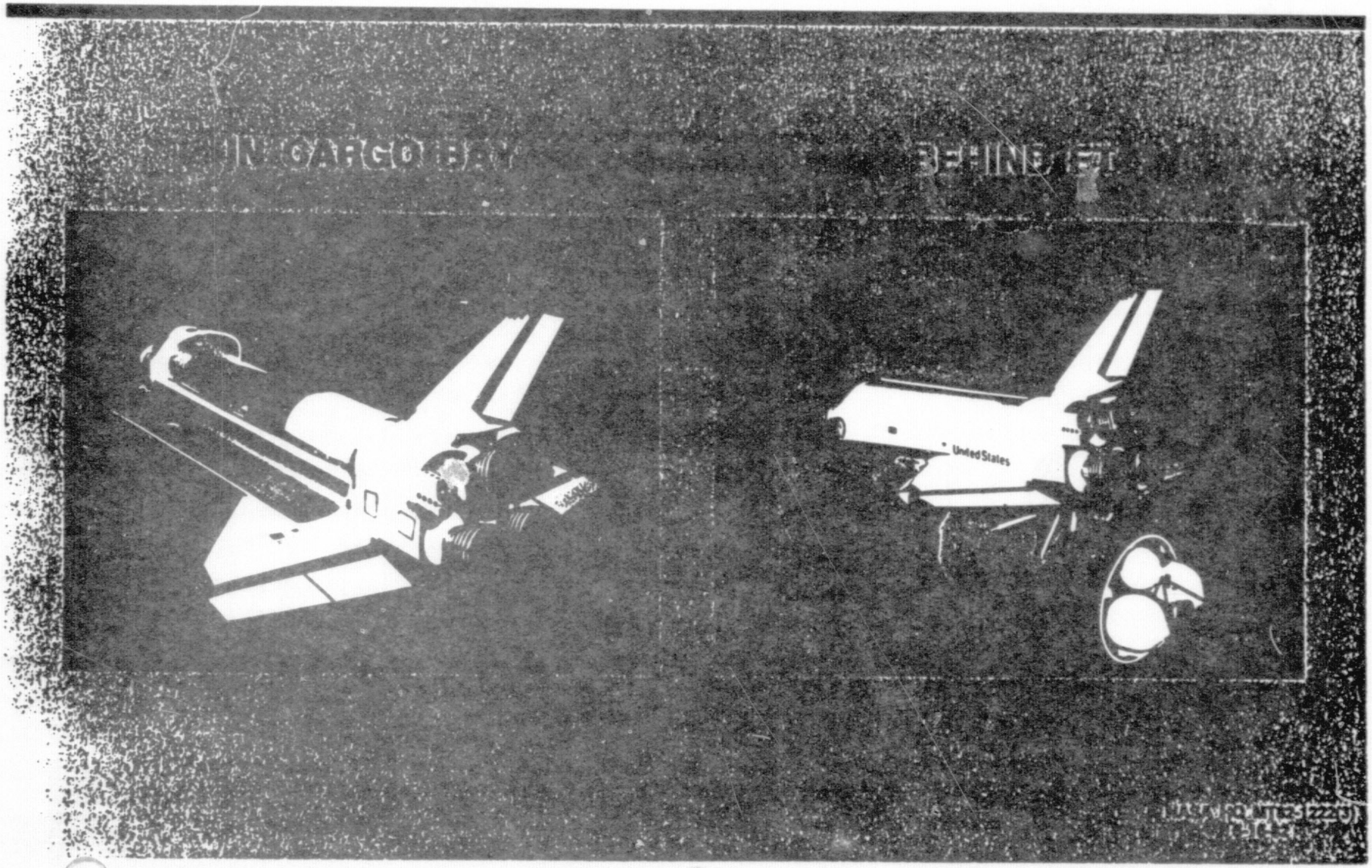
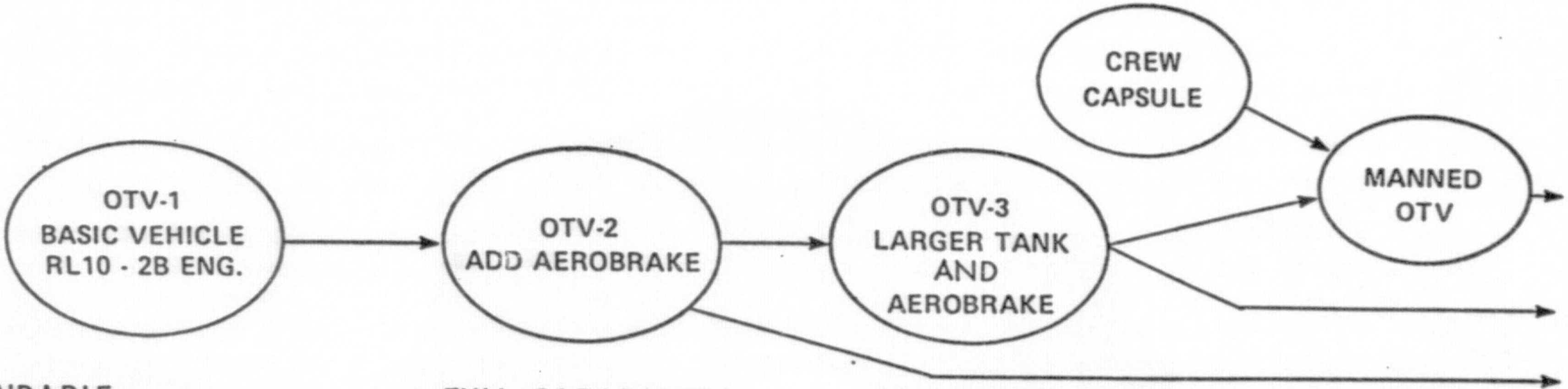


ORBITAL TRANSFER VEHICLE (OTV)



REUSABLE OTV EVOLUTION



- EXPENDABLE
- SIZE FOR AEROBRAKE & LARGER TANK
- 55K PROPELLANT CAPY.

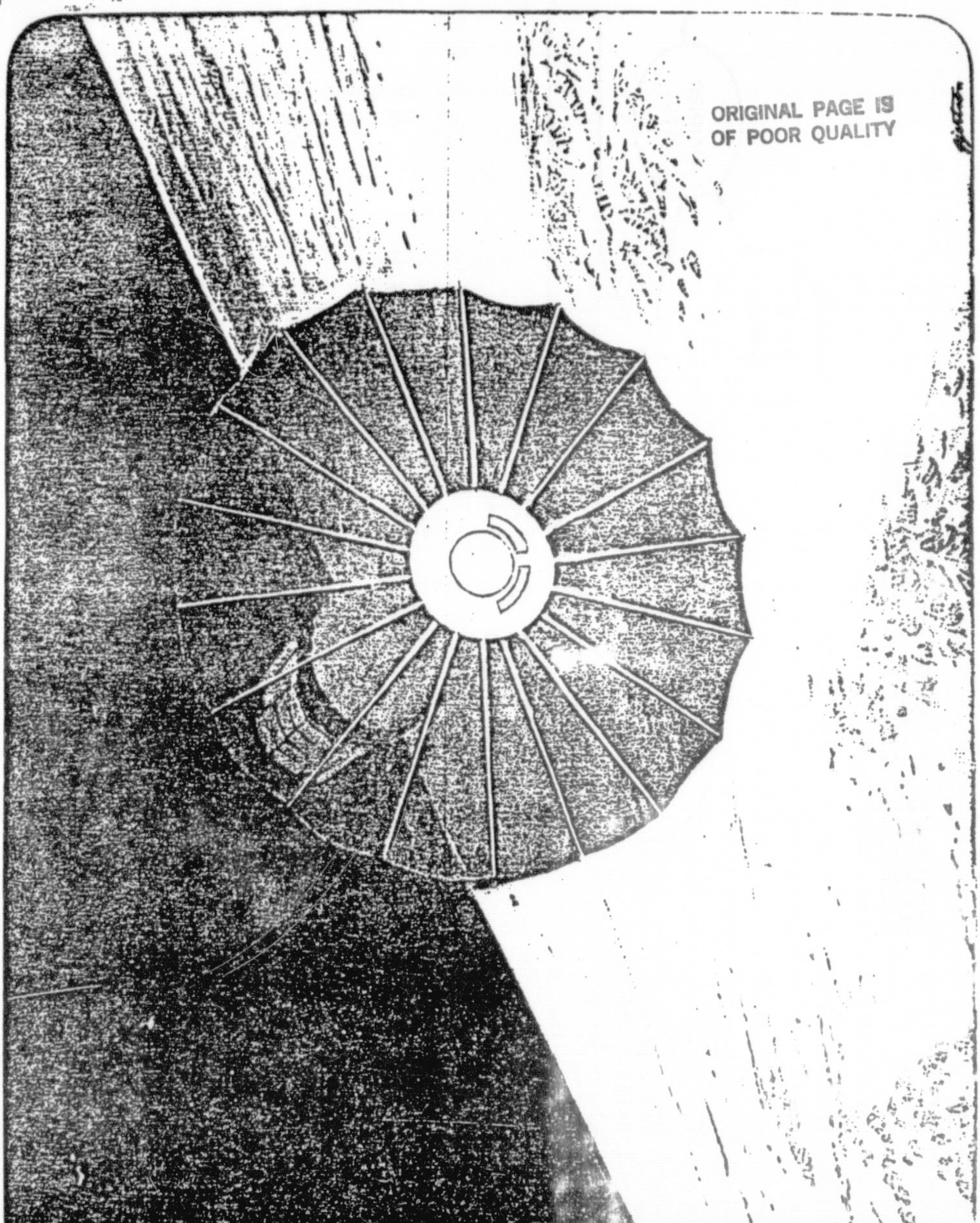
- FULL CAPABILITY (GROUND BASED)
- ADD AEROBRAKE

- SPACE BASED
- MANRATED (2 ENGINES)
- LARGER TANK (75K PROPELLANT)

PAYLOAD POTENTIAL (POUNDS, APPROX.)

	OTV - 1	OTV - 2	OTV - 3
DELIVERY (EXPENDABLE)	21.5K	21.5K	37K
DELIVERY (REUSABLE)	0	16.5K	27K
RETRIEVAL	0	>17K	>28K
ROUND TRIP	0	8.5K	12.6K *

* APPROXIMATE REQUIREMENT FOR "FUNCTIONAL MINIMUM" 2-MAN GEO SORTIE



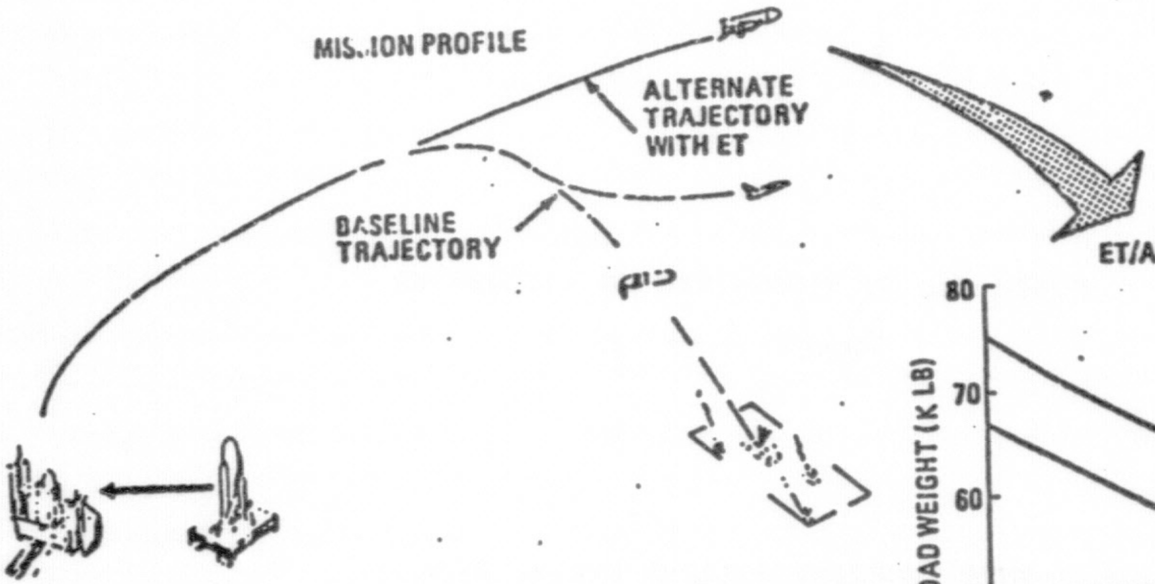
USE OF THE SHUTTLE EXTERNAL TANK

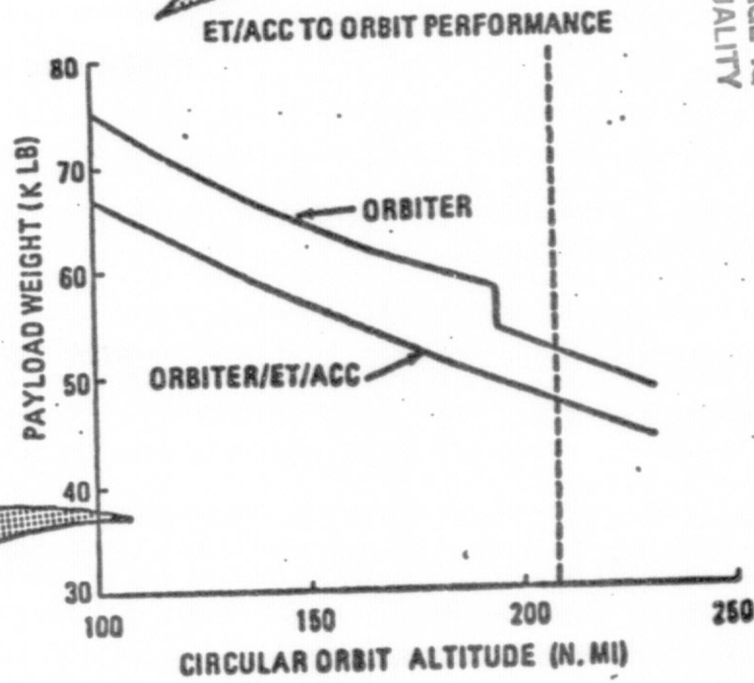
DR. JAMES ARNOLD

UNIVERSITY OF CALIFORNIA AT SAN DIEGO

FIGURE 1

The ET Can Be Placed And Kept In Orbit Easily And Economically





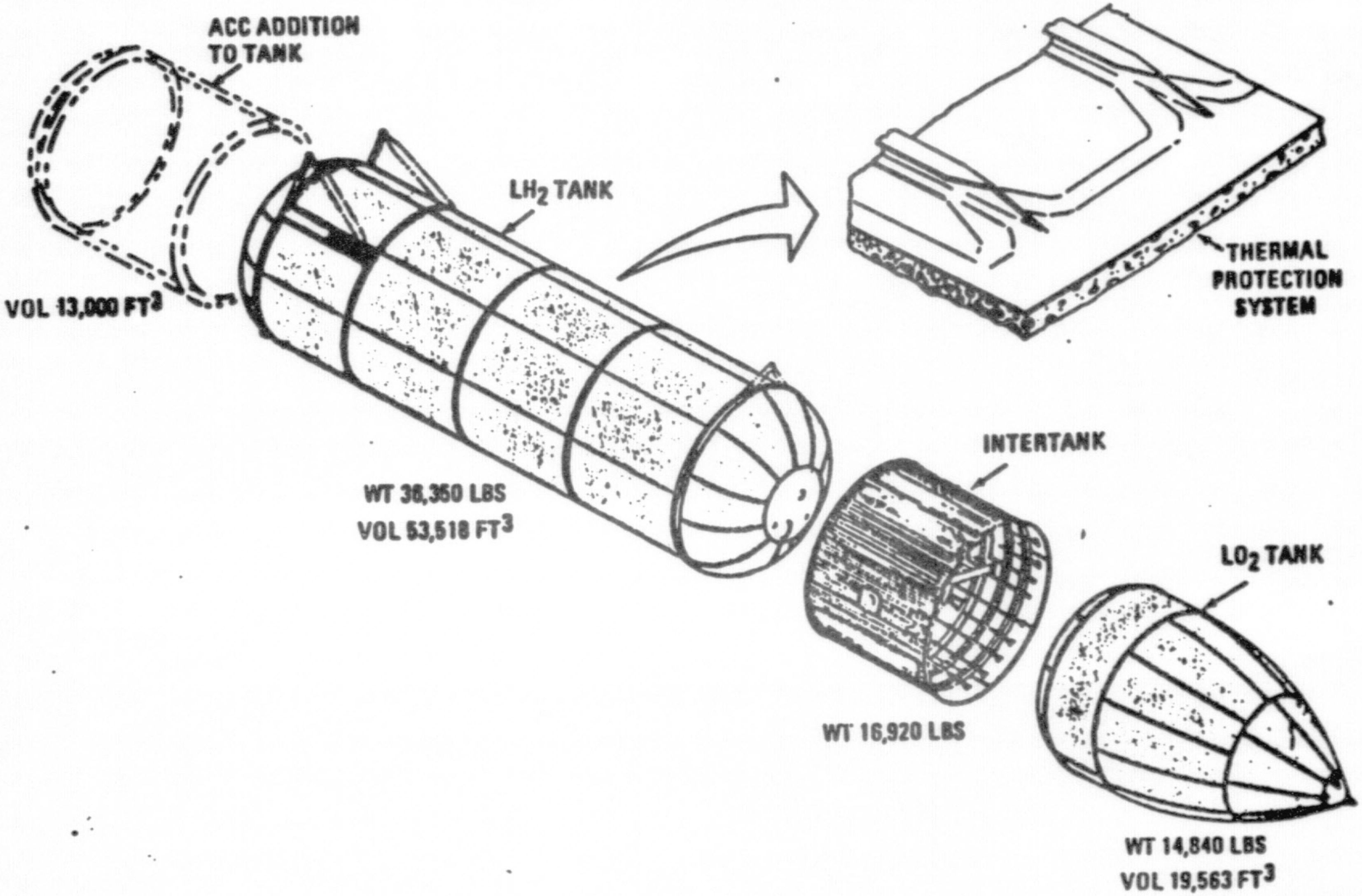
SPACE STATION ORBITAL PERFORMANCE DATA

CONFIGURATION	PAYLOAD (LBS)
ORBITER ONLY	52,000
ORBITER WITH ET	54,000
ORBITER WITH ET/ACC	49,000
ENHANCED STS WITH ET/ACC	65,000

MARTIN MARIETTA

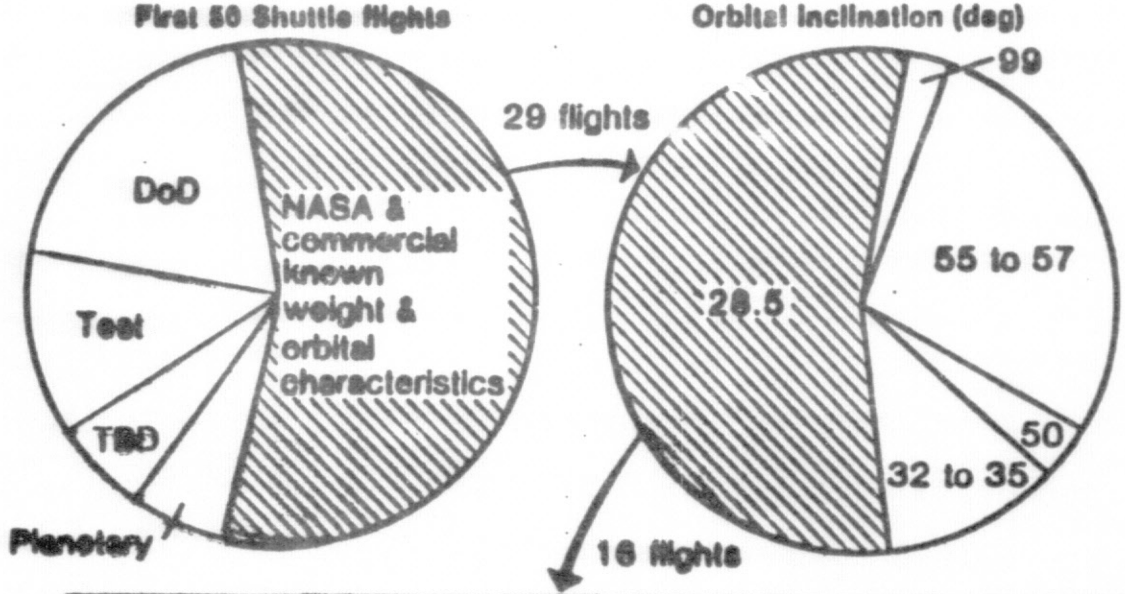
FIGURE 2

The External Tank Is Adaptable For Alternative Uses



MARTIN MARIETTA

SURVEY SHOWS MANY FLIGHTS HAVE EXCESS CAPACITY



	Flight number	Launch Payload (lb)	Orbit Altitude (km)	Shuttle Capability (lb)	Total Equiv Payload (lb)	Excess Capability to 350 km (lb)
1	9	27,273	298	64,600	31,300	33,300
2	12	31,879	400	58,400	32,000	26,400
3	13	39,187	400	58,400	43,200	15,200
15	45	29,280			33,300	31,300
16	46	24,692	370	63,500	24,700	38,800
			Totals	984,600	550,300	434,300

Average contingency payload capability = $\frac{434,300}{984,600}$ = 44%

Adjusted to estimated 20% loss = 35%

KEY RECOMMENDATIONS OF AUGUST 23-27 MEETING

- FLY U.S.-ITALIAN TETHER SATELLITE EXPERIMENT A.S.A.P.
- ET OFFERS OPPORTUNITIES IN THE 1980's WITHIN THE PRESENT STS PROGRAM
- ET APPEARS TO OFFER A BROAD RANGE OF OPTIONS FOR AN INCREMENTALLY DEVELOPED SPACE STATION PROGRAM
- NASA SHOULD CONDUCT SERIOUS AND DETAILED STUDIES OF ET UTILIZATION. REQUIREMENTS FOR ET HARDWARE MODIFICATION SHOULD BE DEFINED. LOOK AT WIDE RANGE OF APPLICATIONS.

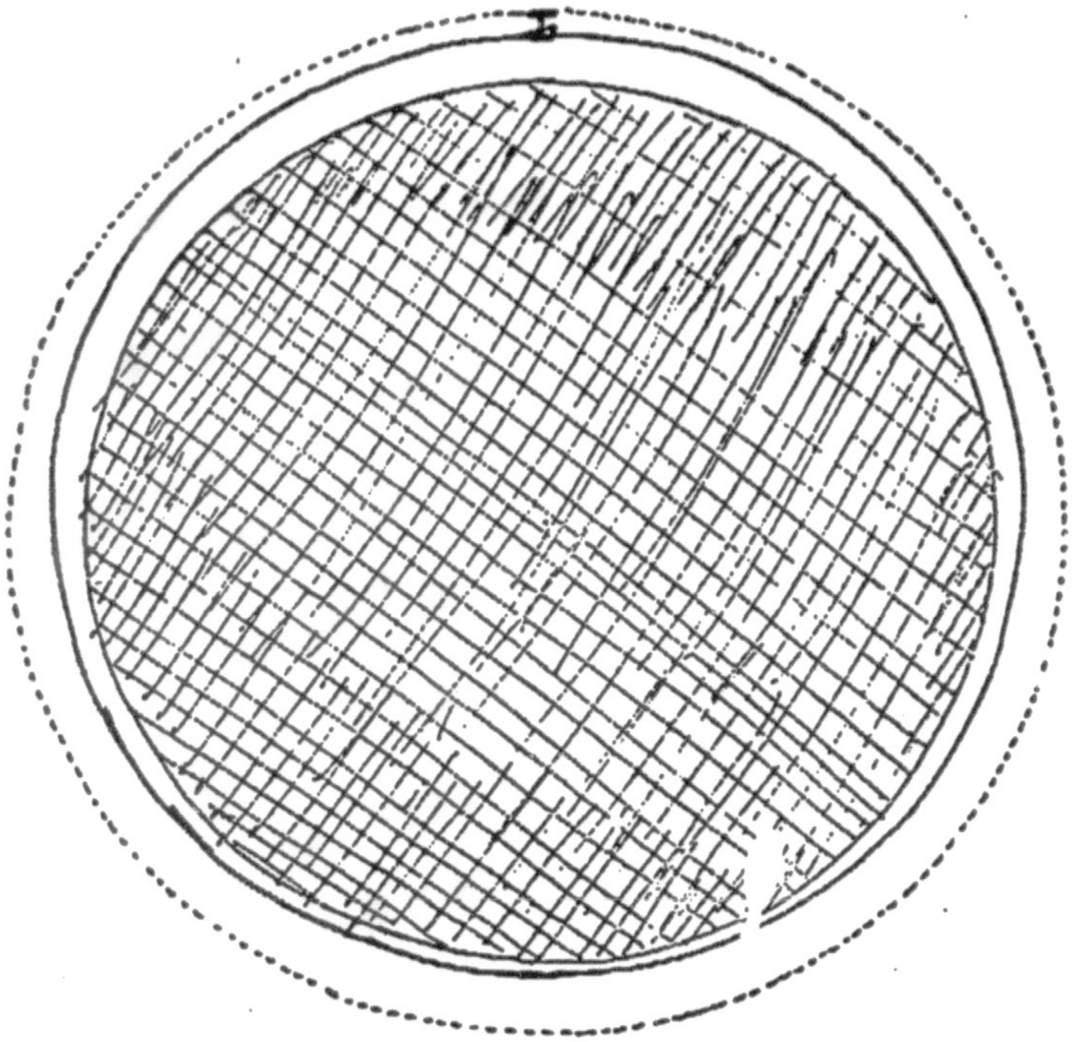


Fig. 5

While the Shuttle is at apogee of a 220-375 eccentric orbit, the release of the E.T. automatically injects the E.T. in a circular orbit at 400 km altitude.

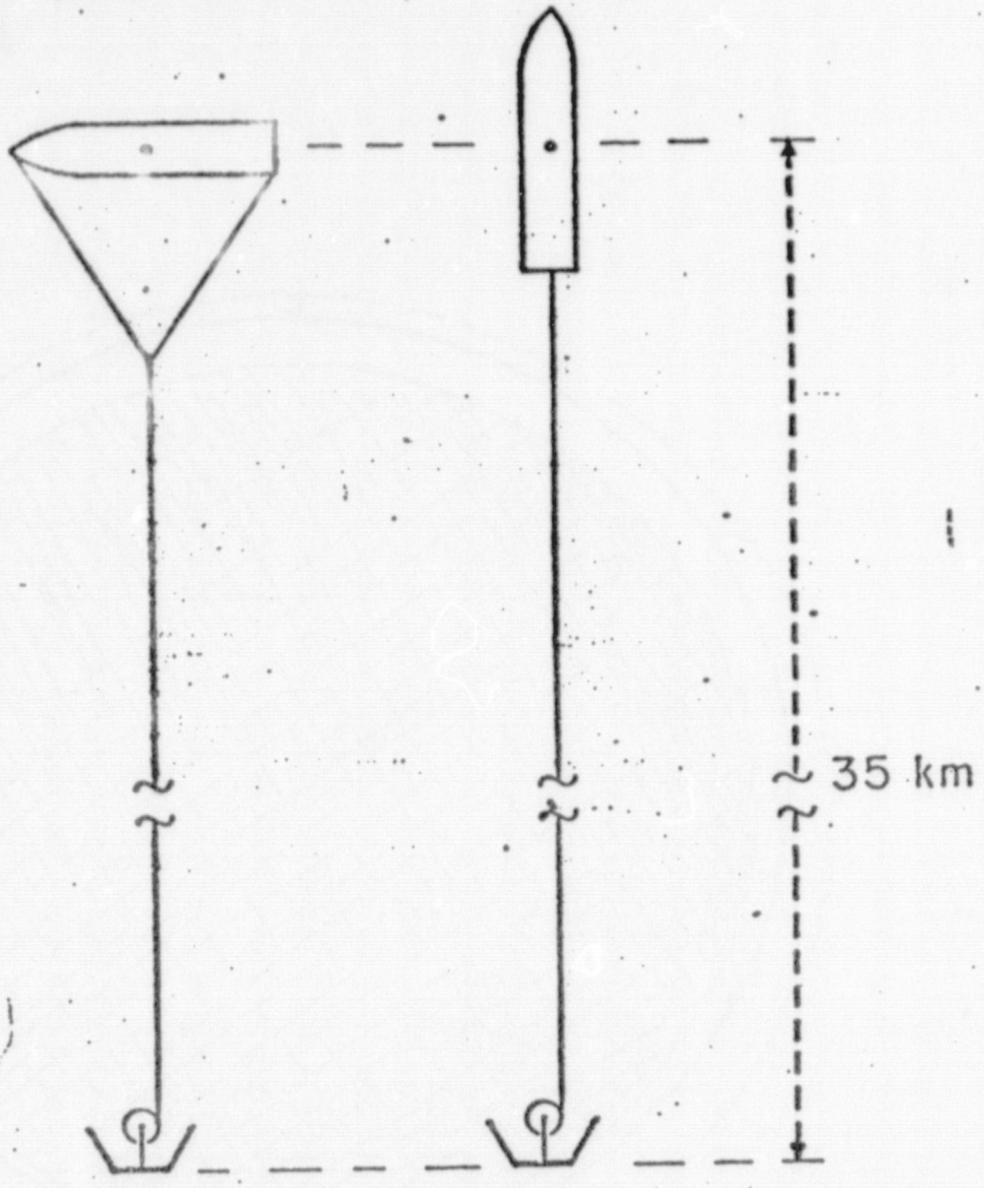
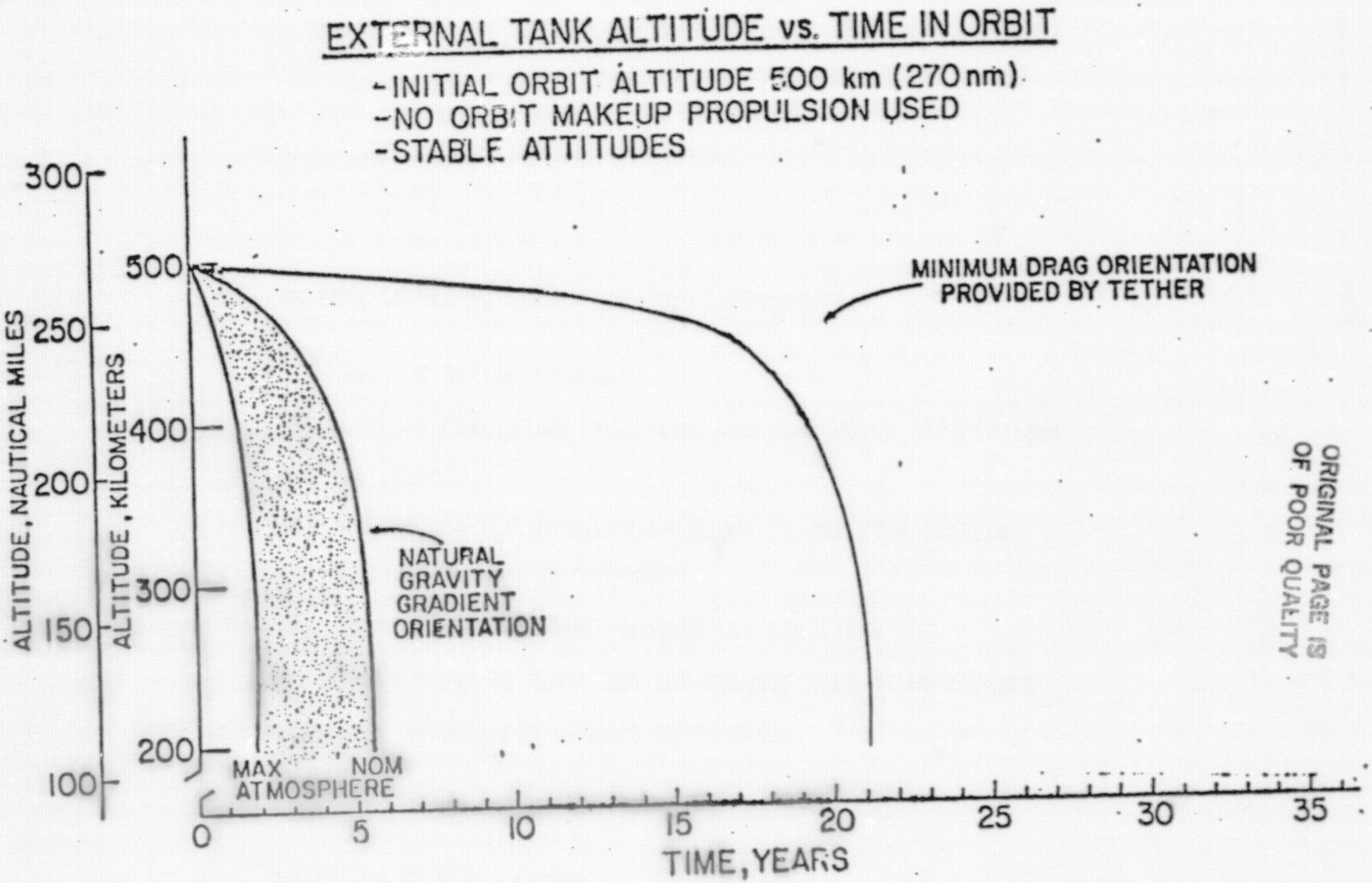


Figure 8. Two possible configurations of an External Tank plus PMDR (Pallet Mounted Deployer-Retriever). The left hand configuration is preferred because it has a lower A/M ratio than the right hand configuration.

FIGURE 3


EXTERNAL TANK ALTITUDE vs. TIME IN ORBIT
-INITIAL ORBIT ALTITUDE 500 km (270 nm)
-NO ORBIT MAKEUP PROPULSION USED
-STABLE ATTITUDES
MINIMUM DRAG ORIENTATION
PROVIDED BY TETHER
NATURAL
GRAVITY
GRADIENT
ORIENTATION
MAX
NOM
ATMOSPHERE
ALTITUDE, NAUTICAL MILES
ALTITUDE, KILOMETERS
300
250
200
150
100
500
400
300
200
0
5
10
15
20
25
30
35
TIME, YEARS

TETHER PRIORITIES AND TASKS

1. FLY TETHERED SUBSATELLITE A.S.A.P. EXPLORE ITS TECHNOLOGY AS BASIS FOR ET APPLICATIONS.

2. PLAN STORAGE OF ONE OR MORE TETHERED ET'S IN ORBIT.

3. TETHER-RELATED ISSUES NEEDING EARLY STUDY:

   (a) ENHANCEMENT OF SPACE STATION CAPABILITIES USING TETHERS

   (b) TETHER MATERIALS AND HARDWARE FOR LONG-TERM USE

   (c) ELECTRODYNAMICS OF TETHERS

   (d) PROCEDURES FOR RENDEZVOUS CAPTURE OF ORBITING OBJECTS BY TETHERS

   (e) PRECISE CONTROL OF EXCITATION AND DAMPING OF OSCILLATIONS

   (f) VARIOUS DESIGN TRADEOFFS

4. CONSIDER TETHER-ET SYSTEMS FOR STS ENCHANCEMENT.

MILITARY APPLICATIONS OF THE ET

ET OFFERS:

- CONCEALMENT
- PRESSURE CAPABLE VOLUME
- SHIELDING
- BED PLATE IN ORBIT
- MOMENTUM
- MATERIALS, PARTS

MILITARY USES OF THESE INCLUDE:

- ON-ORBIT ASSET STORAGE
- TARGET PROLIFERATION
- SENSOR STORAGE/BASING
- SOURCE OF BALLISTIC MATERIALS
- DEEP SPACE TRANSPORT ELEMENT

MILITARY APPLICATIONS OF THE ET

ET OFFERS:

- CONCEALMENT
- PRESSURE CAPABLE VOLUME
- SHIELDING
- BED PLATE IN ORBIT
- MOMENTUM
- MATERIALS, PARTS

MILITARY USES OF THESE INCLUDE:

- ON-ORBIT ASSET STORAGE
- TARGET PROLIFERATION
- SENSOR STORAGE/BASING
- SOURCE OF BALLISTIC MATERIALS
- DEEP SPACE TRANSPORT ELEMENT

TABLE I

External Tank

	WT. lbs.	% of Dry Wt.	
Forward tank	12,352	17.9	
Inter tank	12,080	17.5	
Aft tank, LH_2	28,900	41.9	
Separation Hardware	4,743	6.86	
Propulsion lines	3,760	5.45	Wt. metals
Miscellaneous	1,000	1.45	less misc.
			61,835
	62,835	91.06	
Insulation	6,190	8.94	
	69,025	100.00	

	% of total wt.	# of Material
Alloy 2219	64.44	44,480
2024	19.34	13,349
7050	3.3	2,278
7075	0.87	601
21-6-9	0.93	642
Inconel 718	0.44	304
Ti 6-4	0.31	214
	89.63	
Polyurethanes	5.54	3,824
Silicone Resin & Ablatives	2.3[illegible]	1,636
Foams & Adhesives	1.03	711
Miscellaneous	1.45	1,001
	10.39	69,0[illegible]

69,025

Al	=	56,490#	
Cu	=	3,450	
C	=	2,760	
O	=	1,725	
Si	=	690	
Fe	=	415	13 elements
Mg	=	268	from 200 to
Zn	=	173	35,000#
Ni	=	200	C, H, O, N
Ti	=	220	9 metallic or
Cr	=	188	metalloid
H	=	466	
N	=	246	
Others	=	1,807	(Co, Mo, V, etc)
		69,022	

EXAMPLES OF POSSIBLE FIRST USES OF ET IN ORBIT

- PROOF OF CONCEPT -- TETHER
- LIFEBOAT
- ENHANCED CARGO CAPABILITY (ACC OR ALTERNATIVE)
- SCIENCE (OCCULTATION, ETC.)
- LONG DURATION EXPERIMENTS (BIOLOGY, COSMIC RAYS)
- MILITARY

STAGES OF ET HARDWARE MODIFICATION AS NOW FORESEEN;

IN APPROXIMATE ORDER

- TANK UNMODIFIED OR WITH TETHER ATTACHMENT
- PROPELLANT SCAVENGING
- 36" AIR LOCK ATTACHED TO PORT OR PORTS; SENSORS AND PERHAPS ATTITUDE CONTROL PACKAGE
- ENHANCED CARGO CAPABILITY -- ACC OR OTHER
- ORBIT BOOST/MAINTENANCE CAPABILITY
- JOINING HARDWARE FOR MULTIPLE TANK ASSEMBLY

PARTICIPANTS BY INSTITUTION

UCSD-CALIFORNIA SPACE INSTITUTE (12)

-OTHER DEPARTMENTS (3)

RAND CORPORATION (1)

TRW INC. (3)

LOCKHEED MISSILES & SP. (1)

HARVARD-SMITHSONIAN INST. ASTROPHYS. (1)

BALL AEROSPACE SYS. (2)

MARTIN-MARIETTA AEROSPACE

-DENVER (1)

-MICHOUD (1)

LA JOLLA INSTITUTE (1)

JET PROPULSION LAB. (2)

GENERAL DYNAMICS-CONVAIR (1)

MASS. INSTITUTE TECHNOLOGY (1)

SCIENCE APPLICATIONS INC. (1)

AEROSPACE CORP. (2)

NASA-AMES (1)

MCDONNEL-DOUGLAS

-Huntington Beach (1)

-St. Louis (1)

LOS ALAMOS NAT. LABS. (1)

ROCKWELL INTERNATIONAL-DOWNEY (1)

NASA--MARSHAL SP. FLIGHT CENTER (1)

PURDUE UNIVERSITY (LAB. APPLIED INDUSTRIAL CONTROLS) (1)

NASA HEADQUARTERS (1)

ENERGY SCIENCES LAB. (1)

TAYLOR & ASSOCIATES (1)

CONSULTANTS (unpaid) (4)

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ISSUES AND PROBLEMS

LIFETIME IN ORBIT

PREVENTING COST GROWTH

DEFINITION OF MAN-RATING

TETHERS STILL UNTRIED

SPACE STATION PROGRAM DEFINITION

ATTACHMENT A

CANDIDATE TECHNOLOGY DEVELOPMENT MISSIONS

PRESENTED AT
CONTRACTOR ORIENTATION BRIEFING
SEPTEMBER 14-15, 1982
NASA HEADQUARTERS
WASHINGTON, D.C.

S. V. MANSON
NASA HQ
RSS-5

FOREWORD

The candidate technology development missions described in this attachment were prepared at the NASA Field Centers with coordination and participation by the Technology Development Working Group (a unit of the Mission Requirements Working Group). The members of the Technology Development Working Group are:

OAST/RSS-5	SIMON MANSON (CHAIRMAN)
OAST/RTS-6	JUDITH AMBRUS, DENNIS FLOOD
OSTS/MTC-3	JESCO VON PUTTKAMER
MSFC	WILLIAM WALES
JSC	FRANK GARCIA, RICHARD KENNEDY
LERC	THOMAS LABUS
LARC	EARLE HUCKINS
ARC	DAVID ENNIS
GSFC	DAVID SUDDETH
JPL	JAMES RANDOLPH

The candidate missions are grouped by Field Center and are listed approximately in the order received. Evaluation, integration and time-phasing of the missions remain to be performed.

The missions were defined by NASA staff and they identify areas of technology need and interest. However, they are not, at present, officially approved NASA projects.

S. V. Manson

S. V. Manson

CANDIDATE TECHNOLOGY DEVELOPMENT MISSIONS DESCRIBED IN ATTACHMENT A

Crew Systems:
- Emesis Station
- Dishwasher/Clothes Washer Appliances

Long Term Cryogenic Fluid Storage Technology
Fluid Management Technology
Fire Safety Technology
Controlled Acceleration Propulsion Technology
Large Space Power System Technology Demonstration
Ion Thruster Effects on LEO Power Systems
Liquid Droplet Radiator

Large Structure Technology Experiments
Attitude Control
- System Identification Experiment
- Adaptive Control Experiment
- Distributed Control Experiment

Zero "G" Antenna Range Communications Experiment
Laser Communication and Tracking Development Experiment
Teleoperator Real Time Communications Experiment
Multi-Frequency High Gain Antenna Control Experiment

Space Structures Technology Development/Dynamics of Lightly Loaded Structures
Spacecraft Strain and Acoustic Emission Sensors
Spacecraft Materials Technology
Spacecraft Control Technology Development
- Advanced Adaptive Control Technology Demonstration
- Advanced Control Device Technology Demonstration
- Thermal Shape Control Technology

Large Antenna Development/LSA Short and Long Baseline Technology Development and Utilization
Earth Observations Instrument Development:
- MAPS (Measurement of Air Pollution from Satellite)
- CO2 Lidar for Atmospheric Trace Gas Concentration and Wind Velocity/Transport Measurements
- Satellite Doppler Meteorological Radar Technology Development
- Microwave Remote Sensing Technology - Passive Systems
- Earthbound Oriented Instrument Development

Advanced Energetics Research:
- Deployment and Testing of Large Solar Concentrator
- Test Solar-Pumped Lasers
- Laser-to-Electric Energy Conversion
- Laser Propulsion Test
- Solar-Sustained Plasmas

Electronics Materials Processing:
- Growth of Compound Semiconductor Crystals
- Growth of Thin Single Crystal Rhodium Wafers

Space Manufacturing and Processing Technology Development /Fabrication of Lightweight Cryogenic Heat Pipes
Space Teleoperator Systems Research/Manipulator Controls Technology
Space Station Acoustics Control Technology Development/Noise and Vibration Habitability Criteria Validation

Active Optics Technology
Cryogenic Lifetime Technology
Space Component Lifetime Technology
Materials and Coating Technology

Large Space Structure Technology
Satellite Servicing Technology
OTV Servicing Technology

Tether Dynamics Technology
Earth Observation Sensor Definition
Earth Feature Identification Analysis Techniques and Automated Systems Definition
Earth Observing Technique Development
Materials Processing Technology
- Process and Technique Analysis and System and Procedure Development

Electrophoresis Separation of Medical Materials Technology
Low Cost Modular Solar Panel Technology
Geodesic Spherical Structures Technology

Zero-Gravity Bromine Phase Separation Experiment

Richard Kennedy
Johnson Space Center

CREW SYSTEMS - EMESIS STATION

I. Mission Objective

To provide the technology development and demonstration of the system required for emesis collection, face wash, and cleanup.

II. Mission Description

By provisioning the initial configuration with an emesis station, this mission will provide for direct crew involvement with the system in the actual operating environment. Operation by the crew will be under simulated conditions or, if required, under actual emesis circumstances.

III. Benefit

Because of the specialized application of this type of system, minimal technology will be available for transfer to the private sector. Any manned space mission with a system capability to accommodate such a station will benefit directly from this technology development for both long and short duration space missions.

IV. Justification

The primary concern with the emesis station development is with the overall crew acceptance of the setup, operation, and cleanup aspects. In-flight experience in the actual operating environment will provide valuable information on design or procedures modifications which may be required.

V. Mission Requirements and Capabilities

A) Orbital parameters - None

B) Mass and volume - The facility will be sized to accommodate two persons

C) Power - No unique requirements

D) Thermal Control - No unique requirements

E) Attitude, stabilization - No unique requirements

F) Viewing - No requirement

G) Environmental constraints - No unique requirements

H,I) Data management, communications, crew timeline - Crew participation in simulated conditions or under actual emesis circumstances as required

J) Operations schedule, maintenance, lifetime - TBD

VI. Space Station vs Free Flyer

This mission will be conducted on the Space Station

Richard Kennedy
Johnson Space Center

CREW SYSTEMS - DISHWASHER/CLOTHES WASHER APPLIANCES

I. Mission Objectives

To provide the technology base for crew support systems required for permanent habitability.

II. Mission Descritpion

This mission will provide the conditions necessary for the technology development and demonstration of appliances required to cleanse eating apparatus and crew apparel. This mission can be accommodated on the initial Space Station configuration with the technology transferrable to the evolutionary growth configuration.

III. Benefit

Because of the specialized application of this type of appliance, there will be minimal technology that is directly transferrable to the private sector. The benefits to be derived will be directly applicable to the evolutionary growth Space Station, future manned military space systems, and other yet undefined long-duration manned space ventures.

IV. Justification

For permanent manned habitability, food service and apparel washing appliances are essential to minimize or eliminate logistical resupply. New technology is required since current techniques are gravity-dependent. This technology, properly developed and demonstrated in an operational environment, can eliminate standard clothing resupply requirements of 2,000 lbs. and 100 cubic feet each 90-day period (8 per crew). The ability of this system to handle space suit liquid-cooled undergarments and the food services can double or triple this savings.

V. Mission Requirements and Capabilities

A) Orbital Parameters - None

B) Mass and volume are TBD but, as a goal, would be equivalent to or smaller than conventional appliances.

C) Power - No unique requirements

D) Thermal control - Method of venting excess heat

E) Attitude, stabilization - No unique requirements

F) Viewing - No requirement

G) Environmental constraints - These are TBD until such time as a concept is defined

H,I) Data management, communications, crew timeline - Crew participation is required to activate, monitor, and deactivate test

J) Operations schedule, maintenance, lifetime - TBD

VI. Space Station vs Free Flyer

This mission should be contained on the Space Station since it requires crew involvement and provides the design operating environment.

John Aydelott
Lewis Research Center

LONG TERM CRYOGENIC FLUID STORAGE TECHNOLOGY

I. Mission Objective

To develop the technology for advanced insulation and long life refrigeration/liquefaction systems to provide long term orbital thermal control of cryogenic liquid storage and supply tanks.

II. Mission Description

Subscale cryogenic fluid storage tanks and refrigeration/liquefaction systems would be tested to establish thermal performance and useful life during the early phases of the Space Station evolutionary process. Selected concepts will then provide design criteria for cryogenic fluid storage and supply systems to provide Space Operations Center consumables and Orbit Transfer Vehicle propellants.

III. Benefit

Earth to orbit fluid transportation costs will constitute a significant portion of both Space Station and Orbit Transfer Vehicle operational expenses. Advanced insulation concepts and refrigeration/liquefaction systems can minimize vent losses from orbital cryogenic fluid storage and supply tanks. In addition, Space Station hydrogen and oxygen consumables and Orbit Transfer Vehicle propellants may be manufactured on-orbit by the electrolysis of water and subsequent liquefaction of the generated gases. The water would be transported to the Space Station as Shuttle contingency payload, thus minimizing Earth to Orbit fluid transportation costs.

IV. Justification

Some component and subsystem testing can appropriately be conducted in ground based facilities and as Shuttle/Spacelab experiments. However, the combination of low-gravity, vacuum, long duration (life testing of refrigeration/liquefaction systems), high power, and the real thermal environment of interest for complete system testing can only be achieved on the Space Station.

V. Mission Requirements And Capabilities

A) Orbital Parameters - None

B) Mass and Volume - Approx. 50% of Shuttle capability.

C) Power - 40 kw (1/20 scale system test)

D thru G) Thermal Control, Attitude, Stabilization, Viewing, Environmental Constraints - None sun facing.

H) Data Management, Communications - Down link required (monitoring too time intensive for S. S. crew)

I) Crew Timeline - Only for experiment abort

J) Operations Schedule - Resupply required (frequency TBD) Maintenance-None Lifetime - Experimental objective

VI. Space Station VS. Free Flying Platform

Safety considerations may dictate that cryogenic fluid storage and supply systems be remotely located or fly in formation with the Space Station (Depot Concept)

C) Power - The power requirements are experiment peculiar. However it is anticipated that both AC and DC power at normal levels available in earth-bound laboratories will be required.

D) Thermal Control - Thermal control for the individual experiments will be experiment peculiar and should not be a requirement of the space station. Thermal control of the laboratory, however, should be available and operational to earth based laboratory values. This issue may be related to environmental control.

E) Attitude, Stabilization - The Laboratory Concept must operate in a gravitational environment which must be capable of providing controlled low acceleration levels. An auxilliary propulsion system will be required to provide this control and is considered a separate technology mission.

F) Viewing - No requirements

G) Environmental Constraints - TBD

H, I) Data Management, Communications, Crew Timeline - The Space Station Technology Development Laboratory will need to be manned to perform technology experiments in real-time. Payload specialists will need to be trained to operate and upkeep Data Management System, conduct tests and transmit data back to earth for subsequent analysis. Crew timelines should be scheduled to eliminate undesireable g-jitter disturbances to experiments.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station VS. Free Flyer

The technology experiments identified have both safety and acceleration control requirements that may require trade studies between Space Station and Free Flyer. In either case, this laboratory should be capable of providing controlled low levels of Reduced Gravity. The laboratory concept is envisioned to provide adequate space, power, thermal control and basic experimental services such as supply air, etc. Experiment peculiar instrumentation would not be a part of this laboratory.

Thomas Labus
Lewis Research Center

FIRE SAFETY TECHNOLOGY

I. Mission Objectives

To provide the technology base for the extinquishment of fires and for the control of combustion processes under low gravity.

II. Mission Description

This mission will provide the base technology required for the extinguishment of fires and for the control of combustion processes in confined environments. In-Space Combustion Technology Experiments involve the interaction between a number of complex physical disciplines such as heat transfer, fluid mechanics, mass transfer and chemical kinetics. Specific technology experiments to determine the effects of low-gravity should be conducted to determine the combustion mechanisms of solid, liquid and gaseous systems.

Many potential Space Station experiments can be conducted in the area of Fire Safety Technology. These missions could substantially benefit from a manned technology development laboratory for their successful conduct.

III. Benefit

Technology experiments on fire safety will provide information to designers of Space Station extinguishment systems. In addition, this knowledge can be made available to materials scientists involved in controlled combustion processes related to In-Space materials processing. Fundamental data on classical combustion processes could be used to validate existing zero gravity theories on such physical phenomena as Droplet Combustion, Flammability Limits, Smoldering, etc. This data would find direct applications in numerous terrestrial situations.

IV. Justification

NASA studies as well as work by recognized experts in the academic and industrial community have provided strong advocacy and justification for combustion research in space. The long-duration, low gravity levels obtainable on Space Station will allow successful conduct of numerous combustion technology experiments.

V. Mission Requirements & Capabilities

A) Orbital Parameters - None

B) Mass, volume, operational envelope mass is TBD but an estimated

volume of four times the Spacelab volume on Space Shuttle may be required for a technology development laboratory. A key element to any manned operating laboratory is space.

C) Power - The power requirements are experiment peculiar. However, it can be anticipated that both AC and DC power as normally available in earth-bound laboratories will be required.

D) Thermal Control - Thermal control for the individual experiments will be experiment peculiar and should not be a requirement of the Space Station. Thermal control of the laboratory, however, should be available and operational to earth based laboratory values. This issue may be related to environmental control.

E) Attitude, Stabilization - The Laboratory Concept must operate in a gravitational environment which must be capable of providing controlled low acceleration levels. An auxilliary propulsion system will be required to provide this control and is considered a separate technology mission.

F) Viewing - No requirements

G) Environmental Constraints - All combustion related technology experiments will probably require venting to release products of combustion.

H,I) Data Management, Communications, Crew Timeline - The Space Station Technology Development Laboratory will need to be manned to perform technology experiments in real-time. Payload Specialists will need to be trained to operate and upkeep data management system, conduct tests and transmit data back to earth for subsequent analysis. Crew timelines should be scheduled to eliminate undesireable g-jitter disturbances to experiments.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. <u>Space Station VS. Free Flyer</u>

The technology experiments identified have both safety and acceleration control requirements that may require trade studies between Space Station and Free Flyer. In either case, this laboratory should be capable of providing controlled low levels of Reduced Gravity. The laboratory concept is envisioned to provide adequate space, power, thermal control and basic experimental services such as supply air, etc. Experiment peculiar instrumentation would not be a part of this laboratory.

David Byers
Lewis Research Center

CONTROLLED ACCELERATION PROPULSION TECHNOLOGY

I. Mission Objective

Determine the feasibility, characteristic, constraints, and interfaces of propulsion systems required for controlled acceleration of space systems and correlate the ground and space characteristics of candidate concepts.

II. Mission Description

Candidate low thrust propulsion concepts will be attached to the Space Station or associated space system if program objectives so indicate. The propulsion systems will be operated to determine the feasibility of and constraints on their use to control accelerations induced by natural and space system forces and torques. Associated diagnostics will assess plume characteristics which cannot be adequately evaluated in ground tests. The performance and lifetime will be evaluated by the use of flight and post flight inspections to correlate space and ground results. The specific propulsion concepts to be evaluated are TBD but will include resistojets operated (1) in several modes which affect their dynamic thrust characteristics and (2) possibly with various propellants.

III. Benefit

Sustained controlled acceleration environments for space systems are enabled by low thrust, precisely controlled, propulsion systems.

IV. Justification

Shuttle mission characteristics, priorities, and constraints preclude its use for the evaluation of acceleration control as well as the full accomplishment of correlation of space and ground characteristics. Ground tests are inadequate due to limited pumping, "wall effects", and the lack of sustained low "g" availability.

V. Mission Requirements and Capabilities

A) Orbital Parameters - No constraints except altitudes above those which produce an overall drag of 10-3 "g" or greater.

B) Mass, volume, operational envelope - TBD but the dry mass, including power will typically less than 25KG. The propellant mass is dependent on experiment conditions but would be expected to be less than 20KG. The volume of individual propulsion systems will be less than 0.1 M3. Operational envelope is TBD.

C) Power - Continuous power during the experiment. Either AC or DC power is acceptable but DC is desirable. Other interface requirements are TBD. The magnitude will be greatly dependent on the experiment but would be about 1.5 KW if a full SOC (50KW size) concept were used at 350 KM and correspondingly smaller for smaller experimental platforms at higher altitudes.

D) Thermal Control- Except for propellant management, there are no thermal control interface requirements. For non-cryogenic propellants it is likely that the thermal control will be contained within the experiment by design. For cryogenic propellants thermal control requirements are TBD.

E) Attitude, Stabilization - No fundamental constraints except for (1) a degree of constancy, and/or control, of accelerations on the Space System during acceleration control phases of the experiment, and (2) attitudes required to avoid impacts of the plumes from the propulsion systems.

F) Viewing- No requirements.

G) Environmental Constraints - TBD

H) Data Management, Communication - Basic experiment control is closed loop except for commands to initiate, change state, and terminate the experiment in planned formats. No real time data required except as determined to be needed for space system safety.

I) Crew Timelines - Could be impactive if the experiment is on a manned space system. If crew movements and actions do not affect the experiment, such as on a free flyer or a loose coupled attached structure, the impact of the experiment is probably negligible.

J) Operations Schedule, Maintenance, Lifetime - No maintenance planned. Schedule and lifetime are experiment specific and are TBD.

IV. Space Station VS. Free Flyer

It is likely that uncontrolled accelerations generated on a Space Station from any source are not acceptable. Approaches to avoid such accelerations are TBD but clearly could include free flyers. If free flyers were employed the objectives of evaluation of acceleration control could be achieved without retrieval but full evaluation of the performance, lifetime, and plume interfaces could not, as post test data are required.

Martin Valgora
Lewis Research Center

LARGE SPACE POWER SYSTEM TECHNOLOGY DEMONSTRATION

I. Mission Objective

Demonstrate the viability of multi-voltage operational scheme for large, high power space power system for space platforms.

II. Mission Description

A large solar array segment (sized up to 20 KW) will be assembled in modular form capable of generating power at various voltages from 200 to 1000 volts. This power will be brought into a collection system where it will be converted to AC (high frequency) for transmission to a power distributor system at least 50 m away. Transmission will be over several lines. Within the power distributor, the power will be conditioned for users (possibly 120v, 60 cycle).

III. Benefit

The experiment would be an enabling technology experiment, demonstrating the capability of building modularized space power systems to hundreds of kilowatts for operation in the space environment.

IV. Justification

Future space platform missions are projected to require 100 KW and larger power systems. At these high power levels, the operating voltages for the power generators must be increased to minimize harness losses. Operations at elevated voltages result in possible detrimental interactions with the space plasma environment. Hence, a compromise between the operating voltage required to minimize harness losses and voltages to minimize environment losses must be reached. Such a compromise is the proposed D.C. generation, A.C. transmission concept. In this system, power is generated in modularized solar array systems operating at a voltage compatible with environmental interactions, collected and converted to A.C. for transmission over the large distances to the electrical load distribution system.

The proposed experiment would be a verification of design concepts enabling the construction of larger systems. All of the elements of this space power system would be incorporated. The operation in the space plasma environment over extended periods of time would demonstrate the viability of the system and the understanding of plasma interaction concepts. Such an experiment could not be run from the Shuttle due to the system size and length of time required to justify extension to multiyear operations.

V. Mission Requirements & Capabilities

A) Orbital Parameters - Operation in equatorial-like environments at altitudes of 300 to 400km with arbitrary inclination. (Space platform altitudes)

B) Mass, volume, operational envelope - The proposed experiment includes an approximately 15kw solar array divided into 3 circuits. Each of the 5KW blocks of cells is modularized so that the operating voltage can be controlled. From the power generator 3 transmission lines (50m long) run to the power distributor. The DC to AC conversion system will be located at the generator end of the system. Low frequency, A.C. power would be available at the distributor end for use of the space platform.

The mass has not been estimated as yet. The area of the array is about 150 square meters. It is proposed that this system function in sunlight for at least 6 months to complete the interaction evaluation. This includes the orbital eclipse shut-downs.

C) Power - Experiment will provide own power.

D) Thermal control - Self-contained thermal control subsystem.

E) Attitude, Stabilization - Power generator must be sunlit and held in nominal normal solar incidence on solar array.

F) Viewing - No shadowing of array by space structure allowed.

G) Environmental Constraints - System must function in space environment.

H) Data Management, Communications - Output parameters of system will be monitored. All measurements involving high voltage will be conditioned to be compatible with existing command and data systems.

I) Crew Timeline - Not applicable

J) Operating Schedule, Maintenance, Lifetime - It is desired to turn on this system and leave on for a minimum of 6 months. Data will be collected and analyzed. Operational mode changes will be commanded in as appropriate to obtain desired information. (This could be done by automated sequences). There should be no maintenance required.

John Stevens
Lewis Research Center

ION THRUSTER EFFECTS ON LEO POWER SYSTEMS

I. Mission Objectives

To obtain essential knowledge on power systems operating in an ion thruster generated plasma plume which is needed for design and development of advanced photovoltaic space power systems with high power and high voltage.

II. Mission Description

Prototypes of advanced photovoltaic space power systems must be operated in the vicinity of an ion thruster in order to gain essential experimental data. This data will be analyzed to yield basic knowledge about the physical processes and ultimately verification of analytical models and practical power system designs.

The effects of both natural plasma environment and ion engine generated plasma environment must be determined. Power losses, array degradation and electromagnetic interference are of major concern and must be carefully controlled.Data must be obtained for a variety of thruster propellants and useful for array type, size and voltage scaling.

Both plasma and concentrator solar arrays must be analyzed and tested including the effect of modifications incorporating mitigation techniques such as insulating and biasing. Operating constraints such as configuration and spacing from thrusters must be determined.

The effects to be studied are:

- o Pinhole effects at positive potentials, secondary emission
- o Sheath processes, non-linear expansion with potentials
- o Magnetic field constraints on particle trajectories
- o High electric field emission of electrons
- o Ultraviolet radiation effects - photoemission
- o Ram and wake effects due to spacecraft velocity
- o Arc and corona breakdown (avalanche) effects

III. Benefits

High power high voltage missions of the future can not be enabled

without knowledge of physical processes involving the interactions of the electrical power system and the natural and ion engine generated plasma environment. Protective design techniques will be analyzed, designed, implemented, tested and developed assuring a high reliability final design approach that will then be demonstrated.

IV. Justification

The Space Station facility is required for this mission because of: the large separation distances required between the ion source and the power system, the operation of large scale, high voltage, prototype solar arrays and, the high vacuum requirement.

V. Mission Requirements and Capabilities

A) Operation in equatorial-like environments at altitudes of 300 to 400km with arbitrary inclination. (Space platform altitudes)

B) Mass, Volume, Operational Envelope - The mass has not been estimated as yet. The area of the array is about 150 square meters. It is proposed that this system function is sunlight for at least 6 months to complete the interaction evaluation. This includes the orbital eclipse shut-downs.

C) Power - Experiment will provide own power including power to the ion thruster.

D) Thermal Control - Self-contained thermal control subsystem.

E) Attitude, Stabilization - Power generator must be sunlit and held in nominal normal solar incidence on solar array. During normal operation, ion thruster shall be pointed opposite to the direction of travel.

F) Viewing - No shadowing of array by space structure allowed.

G) Environmental Constraints - The power system must operate in the undisturbed flow of natural space plasma and not in the wake of the space station. Operation during worst case of the natural plasma (solar activity, etc.) is desired.

H) Data Management, Communications - Output parameter of system will be monitored. All measurements involving high voltage will be conditioned to be compativle with existing command and data systems.

I) Crew Timeline - Not applicable

J) Operations Schedule, Maintenance, Lifetime - It is desired to turn on this sytems and leave on for a minimum of 6 months. Data will be collected and analyzed. Operational mode changes will be commanded in as appropriate to obtain desired information. (This could be done by automated sequences). There should be no maintenance required.

Tneodore Mroz
Lewis Research Center

LIQUID DROPLET RADIATOR

I. Mission Objective

Demonstration and technical verification of an advanced Liquid Droplet space radiator concept under acutal operational space station conditions (zero-gravity, space vacuum, space plasma, attitude control manuevering perturbation, etc., during long duration operations). Determine operational characteristics, constraints and effects of space station/radiator interface.

II. Mission Description

The candidate liquid droplet radiator systems could be intergrated/connected to the space station thermal management system at the heat rejection interface point. The system assembly would be installed as an auxilliary experimental heat rejection system. Waste heat load would be supplied by the space station (as an option a separate heat source could be used) commensurate to the size of the liquid droplet radiator system. It would operate at actual space station radiator conditions of inlet and outlet temperature, zero gravity, vacuum, solar radiation, attitude correction and maneuvering perturbations and with the interface of space plasma. Performance would be evaluated for efficiency of waste heat rejection, response, temperature distribution controllability, flow rate, potential of loss of working fluid and space station contamination due to vaporization and manuevering and effect of space plasma interface on liquid droplet streams trajectory. Zero-gravity effects on droplet generation, trajectory and collection efficiency would be determined. Constraint on operation control and performance will be determined. Performance, failure modes, and lifetime potential will be evaluated using operational data to correlate space and ground test data. Mission would require evaluation under startup, shutdown, full and part load operation. A typical system configuration is shown on figure 1.

III. Benefits

Technology verification/demonstration of advanced radiator system less that 1/4 of the weight of flat plate, tube-fin and hear-pipe radiator designs. Radiator concept does not require surface coatings or armor-plate protection. Radiating area is impervious to micro meteroid damage. Liquid droplet radiator is suitable for low temperature (300K) and high temperature (1000K) NASA and DOD applications in KW and MW range. System is deployable, offers compact stowed configuration and can be designed to survive launch environment.

IV. Justification

Evaluation/technical verification of a radiator for space

application requires sustained operation for a long duration under actual spacecraft operating conditions and space environment of zero-G, solar radiation, vacuum, space plasma and the spacecraft steady state, thermal and manuevering operating modes.

Ground testing lacks sustained zero-G, space plasma and solar radiation availability and does not adequately simulate structual forces or manuevering modes. Shuttle mission objectives, limited mission duration and mission priorities preclude its use for sustained long duration testing and may also limit the size of the experiment.

V. Misson Requirements and Capabilities

A) Orbital Parameters - No constraints. Would operate at space station altitude.

B) Mass, Volume, Operational Envelope - TBD. The test radiator systems should be of specific size, compatible with the space station to provide design/operational data that can be used for scaling to a larger system.

C) Power - Ac-DC continuous electric power would be required for pumping and controls. Other interface requirements are TBD. Magnitude of power requirements are dependent on the size of the experiment.

D) Thermal Control - The equipment could be designed for rejection of a portion of spacecraft heat load. It is unlikely that thermal control provisions would be required for any of itx components except instrumentation.

E) Attitude, Stabilization - The system would be designed to operate within the attitude and stabilization constraints of the space station. Position control of the liquid droplet steam collector may be required. It is anticipated that this would be effected through motorized control.. Method is TBD.

F) Viewing - TBD

G) Environmental Constraints - TBD

H) Data Management, Communication - Experiment control is required to initiate operation, terminate operation and change operating level per waste heat rejection demands. Data acquisition is required for operational control and evaluation.

I) Crew Timeline - TBD. Crew resources may be needed for conduct of experiment at scheduled times.

J) Operations Schedule, Maintenance, Lifetime - No maintenance is planned. Schedule and lifetime are experiment specific and are TBD.

K) Economic or Performance Benefits Achieved Through Use of a Space Station - A space radiator system is operation with power production for long durations. The use of a space station for evaluation of this concept offers the potential of long term testing (not available with shuttle) needed for scaling.

L) Space Station VS Free Flying Platform - TBD.

LARGE STRUCTURES TECHNOLOGY EXPERIMENTS

I. Mission Objective

To provide a technology base for the design and analysis of very large space structures having dimensions larger than are compatible with Space Shuttle experiments.

II. Mission Description

Assembly and testing of very large space structures will require utilization of the Space Station as a base for these activities. Maintaining a long lifetime stable platform for assembly and inertial structural characterization testing is important for the evolution of large structure technology. A large facility that can be used for assembly and environmental testing would be required on the Space Station. This facility would include data acquistion and analysis capabilities mechanical operations support and maintenance capabilities, and a supply of goods and tools to allow modifications to large structure designs while on-orbit. Complete dynamic testing capabilities will be required to determine mode shapes, inertial properties, damping/influence coefficients, and other design parameters necessary to characterize the stability and dynamics of very large space structures.

III. Benefit

Many future manned and unmanned missions will depend on assembly and testing of very large space structures enabling new design concepts for structures having kilometer dimensions.

IV. Justification

The long duration, low gravity, and stability characteristics of the Space Station will be an ideal base for the assembly and testing of very large space structures. The inevitability of the very large space structures as a basis for future space missions is certain.

V. Mission Requirements & Capabilities

A) Orbital Parameters - Low inclination for certain thermal shock experimental missions during solar eclipse. High inclination for long term thermal stabilization (no eclipses) during other experimental missions. High altitude to minimize drag perturbations on large structures.

B) Mass, volume, operational envelope is TBD. Mass of components requiring assembly (many thousands of kilograms) could necessitate multi-shuttle launchs. Volume requirements for materials could also require multiple launches. Operational envelope could be many kilometers in dimension requiring some kind of EVA/Teleoperator system.

C) Power - The power requirements would be in the many kilowatt range to allow the assembly and testing activities.

D) Thermal Control - No requirements identified

E) Attitude, Stabilization - A stable platform is necessary for assembly and some testing. Possible isolation from the Space Station perturbations may be necessary during structural dynamics testing. This may be accomplished using either a free-flyer concept or a tether.

F) Viewing - No requirements identified.

G) Environmental Constraints - Low g environment free from micro-g perturbations.

H) Data Management, Communications - A data acquisition and analysis facility would be required to gather and interpret the structural assembly and testing experiments in real time. A communications link would either be hard wired if the structure were attached to the Space Station (or on a tether), or an RF link would be necessary from a free flyer to the data facility on the Space Station.

I) Crew Timeline - Payload specialists would be trained to assemble and test the large structures. Testing coordination between the on-board data facility and engineering teams on the ground would require detailed event timelines to assure the adequacy and completeness of the tests and iterations required.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station vs. Free Flyer

If the stability of the Space Station can be controlled precisely (e.g. TBD) enough, some testing might be possible while attached to the Station. Some testing will probably require isolation from the Station either using tether system or a free flyer concept.

ATTITUDE CONTROL - SYSTEM IDENTIFICATION EXPERIMENT

I. Mission Objectives

To validate sensing strategy/mechanization, identification algorithms and integrated flight control dynamics reconstruction subsystem; establishing off-line and real-time knowledge of flexible Space Station and payload dynamics.

II. Mission Description

The experiment will consist of distributed excitation and sensing of structure and payloads. Sensor outputs will be recorded for off-line system identification or processed sequentially for on-board identification.

III. Benefit

These experiments will establish in-flight control performance of large flexible structures. In addition, they will determine vehicle intertia/CG and mode shapes and frequencies which will assist future design concepts.

IV. Justification

Accurate control of large flexible structures requires a knowledge of the dynamic characteristics. These experiments are necessary to establish these charactistics which lead to advance control system concepts for the large structures.

V. Mission Requirements & Capabilities

A) Orbital Parameters - High enough altitude to prevent drag effects on structure.

B) Mass, volume, operational envelope - Transporation of large number of elements (TBD) to construct an adequately sized structure to characterize large structure dynamics and control.

C) Power - The power requirements would be on the order of a kilowatt for the excitation and data acquisition systems.

D) Thermal Control - no requirement

E) Attitude, Stabilization - The experiments must be done in a stable environment to assure accurate measurements which would not be affected by Space Station.

F) Viewing - No requirements

G) Environmental Constraints - low g environment from vibration perturbations.

H) Data Management, Communications - A data acquisition facility would be necessary to record and analyze the data. Communications would be by hard wire link if attached to the Station or RF transmission to the Space Station if on a free flyer.

I) Crew Timeline - Random crew motion and on-board equipment vibration must be minimized to achieve clean identification environment. Payload specialists would be needed for assembly and configuration changes.

J) Operations Schedule, Maintenance, Lifetime-TBD

VI. Space Station vs. Free Flyer

If the structural perturbations caused by activities on the Space Station can be minimized, then the experimental structure can be attached. Otherwise, a tethered or free flyer configuration must be used.

ATTITUDE CONTROL - ADAPTIVE CONTROL EXPERIMENT

I. Mission Objectives

To validate performance and stability improvement sensing strategies and mechanization, control gain update subroutines and reconfiguration schemes, and adaptive control algorithms.

II. Mission Description

This experiment will evaluate adaptive control algorithms and measurement hierarchy for an evolving or deploying structure. It will include articulation and reconfiguration of payloads to change system mass properties and evaluate adaptive control designs.

III. Benefit

It is expected that new concepts in attitude control of large space structures will require the development of new algorithms as well as new measures of performance evaluation which will be developed during these experiments.

IV. Justification

Control of large space structures requires the understanding of new control algorithms, in parallel, with the development of various structural configurations. The Space Station provides a unique facility to develop these control schemes in an unlimited dimensional environment with zero gravity.

V. Mission Requirements and Capabilities

A) Orbital Parameters - High enough altitude to prevent drag effects on structure.

B) Mass, volume, operational envelope - Existence of a large structure as an appendage to the Space Station or as a free flying (or tethered) vehicle near the station.

C) Power - The power requirements would be on the order of a kilowatt for the excitation and data acquisition systems.

D) Thermal Control - no requirement

E) Attitude, Stabilization - The experiments must be done in an environment which is structually isolated from the Space Station to assure that the data is not affected by Station perturbations.

F) Viewing - no requirements

G) Environmental Constraints - Experiments require a low g environment with minimum vibrational perturbations from the Space Station.

H) Data Management, Communications - A data acquisition and analysis system would be necessary to record the data and develop control schemes in near real time.

I) Crew Timeline - Random crew motion and on-board equipment vibration must be minimized to achieve clean identification environment. In addition, the paylaod specialists must be able to reconfigure the structure to test the algorithm sensitivities to changes in the structural configuration.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station vs. Free Flyer

If the structural perturbations caused by activities on the Space Station can be minimized, then the experimental structure can be attached. Otherwise, a tethered or free flyer configuration must be used.

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ATTITUDE CONTROL DISTRIBUTED CONTROL EXPERIMENT

I. Mission Objectives

To validate hardware, algorithms and systems for active vibration damping, cooperative payload pointing, modular control, control during deployment, and precision pointing/stabilization.

II. Mission Description

The experiment consists of multi-point payload vibration/shape sensing with a sensor attached to Space Station. Distributed actuation along the experimental structure will allow optimal placement of actuators and control schemes. Articulation and deployment of payloads will assist in further understanding of control variations as the structural configuration changes. A controlled coupling would exist at the interface between the structure and the Space Station.

III. Benefit

This experiment will be the final proof test of control techniques for various configurations of large space structures taking advantage of the control algorithms and concepts developed during the "adaptive control experiments."

IV. Justification

These experiments will validate the accuracy and precision of pointing and control of large space structures.

V. Mission Requirements and Capabilities

A) Orbital Parameters - High enough altitude to prevent drag effects on structure.

B) Mass, volume, operational envelope - Existence of a large structure as an appendage to the Space Station .

C) Power - The power requirements would be on the order of a kilowatt for the excitation and data acquisition systems.

D) Thermal Control - no requirement

E) Attitude, Stabilization - The experiments must be done in an environment which is as structually isolated from the Space Station as possible while being attached through a sensor.

F) Viewing - no requirements

G) Environmental Constraints - Experiments require a low g environment with minimum vibrational perturbations from the Space Station.

H) Data Management, Communications - A data acquisition and analysis system would be necessary to record the data and develop control schemes in near real time.

I) Crew Timeline - Random crew motion and on-board equipment vibration must be minimized to achieve clean identification environment. In addition, the paylaod specialists must be able to reconfigure the structure to test the algorithm sensitivities to changes in the structural configuration.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station vs. Free Flyer

Not applicable

ZERO "G" ANTENNA RANGE COMMUNICATIONS EXPERIMENT

I. Mission Objectives

To expedite the development of large diameter antennas for communication satellites, OVLBI, ODSRS, etc., providing a realistic environment for development and prototype qualification testing of subsystems and equipment for control of surface distortions and feed structure deflections.

II. Mission Description

A facility would be development to provide in SITU pattern measurements of antenna beam quality and multiple simultaneous beam isolation. A Space Station based TMS would be used to provice RF pattern illumination.

III. Benefit

Large antenna systems developed to provide in-situ pattern measurements facility with a co-orbiting teleoperator to assemble and test space based antennas.

IV. Justification

Future near earth and deep space communications will rely on large space borne antennas to minimize transmitter power requirements, increase receiver gain, and allow higher frequency radio links. This experiment will enable the technology development of these large antennas by determining the beam pattern precision and control possible on large antennas.

V. Mission Requirements & Capabilities

A) Orbital Parameters - Low inclination to assure solar eclipse and thermal shock testing. High enough altitude to assure minimum atmospheric drag on large antennas.

B) Mass, Volume, operational envelope - Transportation of structural and surface elements of a large antenna may require multiple Shuttle launches.

C) Power - The power requirements would be less than 1 kilowatt on the Space Station and on the Teleoperator illumination system.

D) Thermal Control - No support requirement from the Space Station.

E) Attitude, Stabilization - The experiments must be done in an environment which has altitude as well as structural stability with perturbations less than TBD μ radians in altitude pointing, TBD μ radians/sec in pointing jitter, and TBD g in structural perturbations.

F) Viewing - No requirements

G) Environmental Constraints - Low g perturbations

H) Data Management, Communications - A data acquisition and analysis facility would be required to record and analyse the antenna gain for the illumination generated by a teleoperator illumination system. A RF link would be necessary between the Space Station and the teleoperator to control its position and other activities necessary to properly illuminate the antenna.

I) Crew Timeline - EVA provisions would be required for varying and changing subsystem components and reconfiguration of "antenna range" for various RF measurements.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. <u>Space Station vs. Free Flyer</u>

The antenna should be attached to a stable Space Station allowing controlled illumination by a Teleoperator illumination system.

LASER COMMUNICATIONS AND TRACKING DEVELOPMENT EXPERIMENT

I. Mission Objectives

To provide the technology base for the development of Medium-Range (<10 km), Low Power (<100 km) Solid State Laser Communication Links using Space Based Laser Optical Technology. In addition, the experiment would enable the development and Testing of a VLSI Superwafer Laser Array.

II. Mission Description

The experiment would utilize "node" assemblies containing laser superwafers. "Nodes" would be placed on various space station appendages and teleoperator. Tests of the communication link between the Space Station and a teleoperator for various attitudes and ranges would include acquisition and tracking tests along with measurements of bit error performance. The experiments would verify that spherical communications coverage is possible around the Space Station. The experiments would require adaptive experimental node placement.

III. Benefit

This communications system will provide redundant spherical communications coverage around the Space Station; will allow simultaneous communications, ranging, and pointing angle data; can be used for data relay and structure position determination; will provide poximity position - orientation data for docking approach; and will support other capabilities including wide bandwidth channels such as digital stereo imaging from a TMU, STS orbiter, or from EVA experiments.

IV. Justification

Any Space Station experiments involving EVA and other activities in proximity to the Space Station will require an advanced communications system developed from this enabling experiment.

V. Mission Requirements and Capabilities

A) Orbital Parameters - No specific requirement

B) Mass, Volume, Operational Envelope - Equipment for this experiment would occupy less than one Shuttle payload bay and mass capability. This assumes an available teleoperator system already on-orbit which can accomodate the the laser nodes.

C) Power - The power requirements would be less than one kilowatt for this experiment.

D) Thermal Control - Laser wafers would require low operating temperatures (e.g. TBD) and thermal control.

E) Attitude, Stabilization - Nominal Space Station altitude control and stabilization would be sufficient.

F) Viewing - Nodes would be located on outboard appendages to minimize blockage constraints.

G) Environmental Constraints - Minimum RFI from Space Station communications systems.

H) Data Management, Communications - A central communications control center would be required to sequence and control the experiment.

I) Crew Timeline - Payload specialists would be needed to EVA activities to locate the Nodes on the Space Station appendages and on the teleoperator.

VI. Space Station vs. Free Flyer

Not applicable

TELEOPERATOR REAL TIME COMMUNICATIONS EXPERIMENT

I. Mission Objectives

To provide a demonstration of RF links required for commands and video for man-in-the-loop control of a teleoperator.

II. Mission Description

This experiment would evaluate the performance of a man in control situation taking into consideration the effects of time delays, video data compression, etc. It will determine acceptable levels of video data compression and could lead to a large "telepresence" experiment including adaptive automated control concepts.

III. Benefits

The experiment could be a part of a larger "telepresence" experiment that would be performed to demonstrate real-time, man-in-the-loop control of free flyers, from the Space Station. The current "multiple access" philosophy of TDRSS is not compatible with many of the RF link requirements for this real-time control application. Direct RF links, with an associated RF subsystem, must be designed and evaluated.

IV. Justification

The real time control between the Space Station and a Teleoperator must rely on the development of a reliable RF link which would be enabled by this technology experiment.

V. Mission Requirements and Capabilities

A) Orbital Parameters - No specific requirement

B) Mass, Volume, Operation Envelope - One STS launch would be sufficient assuming an existing on-orbit teleoperator.

C) Power - The power requirements would be less than 1 kilowatt

D) Thermal Control - No specific requirement

E) Attitude, Stabilization - Nominal Space Station stabilization.

F) Viewing - No requirement

G) Environmental Constraints - Minimum RFI from Space Station.

H) Data Management, Communications - Control facility for RF link experiments required on Space Station. Teleoperator communications link would be developed or enhanced.

I) Crew Timeline - Teleoperator communications experiments using payload specialists.

J) Operations Schedule, Maintenance, Lifeline - TBD

VI. <u>Space Station vs. Free Flyer</u>

Experiment applicable to Space Station and/or Free Flyer communications with a Teleoperator.

MULTI-FREQUENCY HIGH GAIN ANTENNA CONTROL EXPERIMENT

I. Mission Objectives

To develop the technology base for dual frequency high gain multi frequency antennas.

II. Mission Description

The experiment will consist of a multi frequency antenna with mechanical aperature control and limited electronic steering of the composite beam to compensate for fine errors of aperature motion and movement of the Space Station. The experiment will demonstrate composite pattern control and stability when communicating with spacecraft in sychronous orbits. Communications links will be investigated, frequency options will be studied, and optimum combinations will be identified. Frequency selective reflectors, dichroic screens, multi-frequency antennas with mechanical aperature steering and electronic pattern stabilization will be developed. An engineering model of the multi-frequency antenna will be tested in space.

III. Benefit

The need exists for simultaneous operation of communications links at multiple frequencies between the Space Station and a single source. The advantages of single aperature articulation compared to 2 or 3 apertures motion with their effects on Space Station stabilization, induced communications noise, and antenna steering makes this approach necessary.

IV. Justification

The eventual application and utilization in a communication link requires performance demonstration.

V. Mission Requirements and Capabilities

A) Orbital Parameters - No requirement

B) Mass Volume Operational Envelope - Experiment volume and mass would be less than the capability of one of Shuttle launch.

C) Power - The power requirements would be less than one kilowatt.

D) Thermal Control - No requirement

E) Altitude, Stabilization - Nominal Space Station altitude control is sufficient.

F) Viewing - No requirement

G) Environmental Constraints - Low g perturbations minimized.

H) Data Management, Communiations - A data acquisition and analysis facility would be required to control the pointing and other control parameters of the experiment.

I) Crew Timeline - EVA provisions would be required to change out various hardware items included in the experiment.

J) Operations Schedule, Maintenance, Lifetime - TBD

VI. Space Station vs. Free Flyer

The antenna would be attached to the Space Station.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Space Structures Technology Development--
Static/Dynamic Testing

Langley Contact:
B. R. Hanks

Experiment Title:
Dynamics of Lightly Loaded Structures

Mission Objectives:
Determine dynamic characteristics of large structural systems for use in orbital operations where static load requirements are small. The dynamic stiffness and damping characteristics of structures such as antenna dishes and manipulator systems which would be non-functional in 1-G will be studied.

Mission Description:
Candidate structures would be deployed or erected using space station as stable platform. General size class would be 30-100 m. Dynamic inputs would be provided and response data measured using space station as a laboratory. Experiment duration may be one week or more.

Benefit:
Building orbiting space structures of anything other than flimsy components may be unnecessary provided sufficient confidence in such components can be developed in flight experiments. Substantial reductions in launch costs and increases in the utility of large spacecraft may be realized through the use of ultra-light structures.

Justification:
For stated benefits to accrue, methods of predicting large dynamic motions and behavior of flimsy structures are needed. The inherent effects of gravity make any Earth-bound study of such structures invalid. The sizes required preclude 0-G aircraft flights.

Mission Requirements and Capability:
Requires 0-G test environment for one week or more. Structural sizes up to 100m involved for up to one week or more. Space station mounted optical measurement devices are necessary.

Space Station vs. Free Flyer:
Space station provides controlled base from which measurements are made. Eliminates need for flight control system which would likely be difficult or impossible to preclude from adverse effects on experiment. Reduces cost considerably.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Space Structures Technology Development

Langley Contact: Joseph Heyman
MS 499/ X3418

Experiment Title: Spacecraft Strain & Acoustic Emission Sensors

Mission Objectives: Develop technology necessary to examine spacecraft structures and provide long-term structural verification through advanced Nondestructive Evaluation (NDE). Test such systems on early spacecraft missions and improve to meet monitoring needs.

Mission Description: Advanced acoustic emission sensors designed and built into the spacecraft structure will be monitored during the mission by a preprogramed computer. The sensors will be developed and tested on the ground and will take advantage of our current R&D program output to provide state-of-the-art sensors. Additional sensors designed to monitor strain with acoustics and fiber-optic interferometric sensors which have been developed at LaRC will be structurally integrated as well.

Benefit: The life of the Spacestation may very well depend on integrated NDE with the structural design and Quantitatively monitoring material/structural properties during long-term space environment exposure (environment plus control). Proper monitoring may both identify problems before they become critical as well as prevent problems caused by improper control technology.

Justification: Need for real spacestation environment and long duration tests to evaluate methodology.

Mission Requirements and Capability: Spacestation

Space Station vs. Free Flyer:

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Spacecraft Materials Technology

Langley Contact:
D. R. Tenney, W. S. Slemp,
G. F. Sykes

Experiment Title:

Mission Objectives:
To provide a technology data base for long term use of advanced materials in space

Mission Description:
The proposed mission would provide a unique opportunity to develop a long term space environmental durability data base on advanced thermal control coatings, adhesives, composites, and polymer films. Specific experiments would be developed to evaluate the effects of each exposure parameter, both singly and combined, on the properties of these materials. Insitu evaluation of properties could be performed.

Benefit:
Long term exposure data is not available, therefore a data base would be generated that would provide a basis for more efficient space structure design. The generated data would provide verification for ongoing materials exposure programs in ground-based facilities.

Justification:
Long term laboratory simulation experiments are expensive and limited because a complete space environment consisting of extreme ultraviolet, vacuum, atomic oxygen and thermal cycling cannot be duplicated in the Earth-based laboratories.

Mission Requirements and Capability:
Space station is required to provide access for specimen removal, replacement and periodic insitu testing. Power (level TBD) would be essential. Orbit requirements designed to provide maximum environmental expsoure.

Space Station vs. Free Flyer:

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Spacecraft Control Technology Development

Langley Contact:
L. W. Taylor, Jr.

Experiment Title:
Advanced Adaptive Control Technology Demonstration

Mission Objectives:
Evaluate adaptive control techniques required by advanced space station configurations. These adaptive control techniques will include closed-loop systems identification.

Mission Description:
Advanced adaptive control laws will be provided as selectable alternatives to operational control laws. Various advanced techniques will be evaluated with the operational system serving as a backup.

Benefit:
Systems identification and adaptive control technology must continue to evolve as space stations become more complex and flexible. Advanced techniques must be validated prior to operational use.

Justification:
Technology supports space station evolution and therefore requires realistic large flexible structures as a test bed. Ground testing of this technology is not possible.

Mission Requirements and Capability:
Essentially the same as the operational control system. Expanded or modified computational capability is anticipated.

Space Station vs. Free Flyer:
Technology applies to multibody, flexible space stations as opposed to single body, relatively stiff free flyers.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Spacecraft Control Technology Development

Langley Contact:
C. R. Keckler

Experiment Title:
Advanced Control Device Technology Demonstration

Mission Objectives:
Evaluate momentum storage control devices (e.g., third generation control moment gyros (CMG's), second generation magnetically suspended momentum rings (AMCD's)) required by advanced space station configurations.

Mission Description:
Advanced control devices will be provided as selectable alternatives to operational control devices. Various advanced devices will be evaluated with the operational system serving as a backup.

Benefit:
Control device technology must continue to evolve as space stations become more complex. Advanced devices can be qualified in space using the operational system to insure safety.

Justification:
Technology supports space station evolution and therefore requires the space station environment for realistic dynamic testing and long duration life testing.

Mission Requirements and Capability:
Essentially the same as the operational control devices. Expanded software is anticipated for the dual hardware interfaces.

Space Station vs. Free Flyer:
Validation on the vehicle of intended application is desirable. Life testing could be accomplished on a free flyer; dynamic control testing must be performed on a large, multibody, flexible structure.

Mission Title: Spacecraft Control Technology Development

Langley Contact: H. M. Adelman

Experiment Title: Thermal Shape Control Technology

Mission Objectives: Determine the feasibility of controlling shape distortion by on-board heating.

Mission Description: A large flexible panel will be attached to the space station. Heaters will be mounted to the panel at a number of locations. Sensors located on the panel will detect deviations from the required shape and trigger the heaters to generate a temperature distribution in the panel which will offset the unwanted distortions.

Benefit: Control of distortions by thermal means has these benefits relative to control by applied forces: Thermal loads are self-equilibrating and their use avoids possible drift and orientation changes associated with unbalanced forces; solar heating and on-board generated heat is available to activate the heaters; the stresses in the panel resulting from the heat loads would be smaller than those associated with applied forces.

Justification: Verification of the concept of thermal shape control requires a long duration mission in a low-g environment. Ground tests and Shuttle flight tests are precluded because of inadequate facilities to simulate precise conditions of sustained orbital heating and to accommodate the large-sized test article required.

Mission Requirements and Capability: The experiment requires a highly variable thermal load environment characteristic of low earth orbit with periodic shading of the panel by the space station.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: **Large Antenna Development** Langley Contact: **W. L. Grant 3631**

Experiment Title: **LSA Short and Long Baseline Technology Development and Utilization**

Mission Objectives: **Prove enabling technologies associated with short and long baseline LSA receiver system designs suitable for radio astronomy and Search and Rescue use.**

Mission Description: **Short Baseline**--Utilize extreme ends of space station as baseline separation of interferometric antennas.
Long Baseline---Utilize space station and Free Flyer.

Microwave receivers and antennas would be implemented for orbital operation with antenna baseline lengths up to 500 ft. Known earth and galactic targets would be used to evaluate system designs and performance.

Benefits: Improve Radio Astronomy systems and provide baseline evaluation of potential search and rescue techniques.

Justification: **Current radio astronomy methods are limited by fixed earth bound large antennas affected by atmospheric and ionospheric phenomenon. Space bases operation would avoid this problem and allow(for Search and Rescue) full earth surveillance.**

Mission Requirements and Capability: **TBD**

Space Station vs. Free Flyer: **Both. (See Mission Description)**

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Earth Observations Instrument Development

Langley Contact:
H. G. Reichle, Jr.

Experiment Title:
MAPS (Measurement of Air Pollution from Satellites)

Mission Objectives:
To provide technology base for the development of passive remote sensor of atmospheric trace gases

Mission Description:
Modular instruments which would allow changing of components would be flown. Various tests to determine such things as optimum bandpasses, flitering, and scanning could be performed for different instrument concepts and target gases.

Benefit:
Current test methods involve the use of Shuttle sortie missions for techniques development. Lead times for integration are long and available missions are very few in number causing development to be very slow. Accelerated development would allow much earlier global trace gas assessments.

Justification:
Need space environment. Wide geographical coverage affording a variety of atmospheric conditions. Ability to make instrument adjustments on orbit to optimize test results.

Mission Requirements and Capability:
Altitude and inclination not critical. Must be Earth viewing attitude (Nadir $\pm 5^{\circ}$). Weights generally of order 100 kg, power of order 200 watts. Instrument thermal control required.

Space Station vs. Free Flyer:
Free flyer would suffer all disadvantages of sortie mission but to an even greater degree. Free flyer would not allow easy on orbit instrument modifications, hence is not a viable alternative.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Earth Observations Instrument Development

Langley Contact:
R. V. Hess

Experiment Title:
CO_2 Lidar for Atmospheric Trace Gas Concentration and Wind Velocity/ Transport Measurements

Mission Objectives:
To provide the technology for high pulse energy and high repetition CO_2 lasers with high frequency stability and wide tuning range and wide tuning range and long laser life times

Mission Description:
The mission will provide the technology for the mission objectives. Key issues are establishment of the laser characteristics in the space station environment with benefits from the manned technology laboratory

Benefit:
The availability of higher power than on the Shuttle will provide vital information for environmental atmospheric studies and for meteorology for improved weather prediction for civilian and military purposes

Justification:
Demonstration of CO_2 Lidar from the space station with availability of high powers, is of great importance for global environmental and meteroological studies, which cannot be conducted from the ground. The experiment could also be applied to evaluation of rendezvous with non-cooperative targets

Mission Requirements and Capability:
Power requirements of 25 kw and higher

Space Station vs. Free Flyer:
Applicability of experiment to free flyer will be determined by demonstration

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Earth Observations- Instrument Development -

Langley Contact: L. D. Staton 3631

Experiment Title: Satellite Doppler Meteorological Radar Technology Development

Mission Objectives: Develop enabling technology required for pushbroom Doppler radar measurement of global rainfall rates and ocean surface wind vector associated with storm systems and other special meteorological features. Developmental techniques using millimeter waves will also be evaluated to provide three dimensional definition of non precipitating clouds.

Mission Description: A multifrequency spaceborne meteorological radar will be assembled for in-orbit operations in a modularized form so that different and/or additional receiver channels and antenna beams can be implemented as the experiment matures towards a Proof-of-Concept design for potential operational use.

Benefit: Measurement of cloud thickness and height, rain rates, and winds within cloudy environments not accessible to other regions of the spectrum and on a global scale would have enormous benefit to meteorology, crop predictions, flood predictions and related activities.

Justification: Testing of the pushbroom Doppler radar and its ability to make geophysical measurements using a low developmental cost modularized Add-On approach would allow a final cost effective instrument to be realized and at the same time guarantee its usefulness in operational applications.

Mission Requirements and Capability: A relatively large (> 50m) phased array antenna would be assembled by EVA in a modularized form. Attachment to space station (at least in initial configurations) would allow ease of modification of antenna and other radar components as experiments progressed. Space station would house the modularized electronics, data handling equipment, and primary power.

Space Station vs. Free Flyer: Space Station

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: **Earth Observation Instrument** Langley Contact: **R.F. Harrington**

Experiment Title: **Microwave Remote Sensing Technology-Passive Systems**

Mission Objectives: Demonstration of smart sensor technology for passive microwave remote measurements with real time target adaptable sensor mode optimization such as resolution cell size and measurement accuracy.

Mission Description: A multiple frequency, multiple beam imaging microwave radiometer system would be developed and evaluated in space to measure several geophysical parameters simultaneous. These parameters are soil moisture, sea surface temperature, ocean surface wind speed, rain rate, sea ice classification data, atmospheric data, etc

Benefit: This mission is needed to develop and demonstrate the technology for future operational earth observational satellites for measurement of many important geophysical parameters using passive techniques.

Justification: The feasibility of geophysical parameter measurements from passive microwave instruments has been demonstrated using satellite radiometers such as ESMR and SMMR. However, additional microwave instrument and algorithm development work is required to bring these measurements from a feasibility demonstration to an optimum operational basis.

Mission Requirements and Capability: Orbit: Altitude 500 to 1500 km

S/C Interface: Weight 200 kgm
Volume 1.5 m^3
Power 200 watts

Space Station vs. Free Flyer: Space station preferred to take advantage of man-in-the-loop modes necessary to develop smart sensor technology in the most optimum way.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title:
Earth Observations Instrument Development

Langley Contact:
W. E. Howell

Experiment Title:
Earthbound Oriented Instrument Development

Mission Objectives:
To develop instrumentation which senses various Earth-bound phenomena.

Mission Description:
Present space instrumentation which is intended to sense Earth-based phenomena is restricted to highly selected bands in the electromagnetic spectrum (e.g. the visible and relatively narrow RF regions). As our speculation and understanding of various physical processes increase, we will need to develop sensors with an increasingly wide variety of attributes. These sensors will, of course, be initially built and limited testing performed on the Earth; however, full operational potential can be best obtained if developmental testing is done from the space station.

Benefit:
One of the major problems in developing such scientific and operational instrumentation, especially when the physical process to be sensed is only partially understood, is the need for specialized facilities which duplicate the expected environment. For the class of instruments discussed here, the environment of interest is usually related to atmospheric absorption in the new region of interest, effects of various viewing or illumination angles, seasonal variation, and effects of various degrees of cloud cover or moisture content. The space station provides an ideal facility for rapid assessment of these and as yet undetermined factors without continuing major investments in new developmental facilities. Furthermore, it is often the case that the solution of very difficult problems become intuitively clear when all the proper constraints are brought together in such a facility.

Justification;
For these tasks, the space station provides an all encompassing facility with exact modeling of all known and unanticipated phenomena of interest for Earth-oriented sensors.

Mission Requirements and Capability:
Such missions require continuous, or at least long-term (hours) Earth orientation; usually nominal power and environmental control. Some experiments will require sensor cooling ranging variously from nominal through cryogenic.

Space Station vs. Free Flyer:
Manned intervention in the development process is critical to mission success; therefore, a free flyer is inappropriate.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Advanced Energetics Research-I **Langley Contact:** E. J. Conway

Experiment Title: Deployment and Testing of Large Solar Concentrator

Mission Objectives: To develop and deploy a large permanent mirror facility to capture and concentrate AM-0 solar radiation. To accurately establish the optical characteristics of this facility through systematic measurements, and to assess the long-term stability of the optical characteristics of the mirror.

Mission Description: The mission will provide the facility necessary for other Advanced Energetics missions. It will require development and deployment of a large stable concentrating reflector, and will permit assessment of the stability of 1) reflecting optical coatings, and 2) mechanisms for producing and holding optical quality reflector shapes in the space environment.

Benefit: This facility would be required for other experiments and would be a test item itself for optical coatings and shape.

Justification: Currently, space solar energy is only used as a power source with large flat plates of photovoltaic cells. Other conversion schemes for solar energy (such as solar-pumped lasers, solar-sustained plasmas and solar thermal engines) have been conceived, but most require solar concentration. This mirror would provide the well-characterized, high-quality concentrator in the AM-0 environment necessary to properly develop and test advanced energy concepts.

Mission Requirements and Capability: The facility will require pointing and tracking to be useful. EVA will be required for deployment and intensity mapping.

Space Station vs. Free Flyer: A significant effort will be required to deploy a large high-quality reflector. More effort will be needed to characterize its operation. Thus, it requires man in the set-up loop. Later it will require man to install, checkout, operate, and repair advanced experiments. This facility requires a manned spacecraft with a mission life that is very long compared to the set-up and mapping time for the mirror.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Advanced Energetics Research - II **Langley Contact:** E. J. Conway

Experiment Title: Test Solar-Pumped Lasers

Mission Objectives: To demonstrate, calibrate, and test the operation of a solar-pumped laser using the AM-0 solar spectrum and to use a large, high-quality optical concentrator deployed and characterized as an earlier mission objective. To provide a realistic comparison of several solar laser types.

Mission Description: The mission will demonstrate for the first time solar-pumped lasing using the full solar spectrum (rather than a simulated spectrum). It will provide for the accurate measurement of solar laser efficiency which is spectrum and temperature-dependent and will provide for long-term operation to assess lasant stability and lasant reconstitution efficiency.

Benefit: Solar-pumped lasers offer potentially revolutionary advances in space power and propulsion. This will be their first severe space test. Solar-pumped lasers offer low-maintenance, low-cost solar conversion. Long-term tests will assess the claim of low maintenence. Several lasants can be compared.

Justification: Lasers offer very important cost benefits for space propulsion and may be economical for space electric power, communications, and space processing. Trial and development of this technology is crucial to establishing its feasibility and reliability.

Mission Requirements and Capability: The mission will require accurately repeatable pointing of the concentrator toward the sun and away from it. Placement of the laser in the calibrated focal region of the concentrator and attachment to thermal radiators will require EVA. Laser power and temperature measurements may also require human help.

Space Station vs. Free Flyer: The human involvement required in installing the laser and making measurements and lasant changes requires a manned spacecraft. Long-term operation (on the order of weeks or months) requires a long-duration, manned spacecraft. Also, if the high-quality concentrator on the space station, then the laser test must also be on the space station.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Advanced Energetics Research - III **Langley Contact:** E. J. Conway

Experiment Title: Laser-to-Electric Energy Conversion

Mission Objectives: To characterize and compare for space operation the performance of laser-to-electric power converters, and to demonstrate short-range laser-power transmission in space.

Mission Description: Using a solar-pumped laser deployed and characterized under an earlier mission objective, transmission over the longest spacecraft dimension will be performed and the intensity pattern at the convertor site measured. An assessment of convertor performance, efficiency, stability for long-term operation and resistance to environmental interference or degradation will be performed for a set of convertors.

Benefit: By flight time, terrestrial R & D will have developed several useful laser-to-electric power conversion devices. Their efficiency, stability and reliability will require extensive space testing. Their environmental interaction and the maturity of the technologies will be assessed and improved as required.

Justification: The high cost and limited quantity of electric power in space has been identified as a limiting factor to expanding space activities. A change of function, from each spacecraft generating its own power to specialized central power stations producing and beaming power, could provide much more available power at reduced costs. R & D to assess these possibilities will require substantial space testing.

Mission Requirements and Capability: The major requirements will be periods of manned interaction, long-term constant power operation of the laser and recording of data for post-flight study.

Space Station vs. Free Flyer: This program requires man tended operation and use of calibrated and operational facilities already developed and in place on the space station from earlier experiments.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Advanced Energetics Research - IV **Langley Contact**: E. J. Conway

Experiment Title: Laser Propulsion Test

Mission Objectives: To measure the thrust and specific impulse of one or more laser propulsion systems, and to assess the adequacy of ground-based measurements, and to test the life expectancy of a laser engine.

Mission Description: The mission will be the first systems-level test of laser propulsion in space. It will test thrust and specific impulse as well as system characteristics such as steady-state wall temperature, propellant mass flow rate. A high-power laser, either solar-pumped or electrically pumped, will be required for this mission. Life tests will be performed.

Benefit: Studies show that laser propulsion offers large cost savings for OTV's operating in a heavy traffic mode. By the early 1990's, prototype laser propulsion systems will be developed and tested on the ground. Their further development will require verification by a space test of the performance in test chambers. This mission is designed to test propulsion system parameters and establish a reliable estimate of benefit.

Justification: Several studies have shown that laser propulsion for OTV applications could be much less expensive than chemical propulsion. Without aggresive research, technology development will not be realized. This mission is designed to demonstrate and advance the state of the art in laser propulsion.

Mission Requirements and Capability: An adequate laser power source operating at the correct optical frequency will be required. Laser pointing and tracking will not be required since transmission can be over a distance of approximately the longest dimension of the space station. Adjustment, control, alignment, and repair are expected to require manned interaction. Depending upon the magnitude of the laser thrust, an opposed non-laser engine may be required.

Space Station vs. Free Flyer: These tests will require man for deployment, to achieve and measure maximum performance and to assure safety for the spacecraft and the laser propulsion system. Because it requires a high-power laser, either solar-pumped (requiring the concentrator) or electrically pumped (requiring a large photovoltaic panel), the resources of a space station will be required.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Advanced Energetics Research - V **Langley Contact:** E. J. Conway

Experiment Title: Solar-Sustained Plasmas

Mission Objectives: To demonstrate, contain, and characterize solar-sustained plasmas and to operate, assess, and refine MHD electric power generation in space and plasma thruster performance.

Mission Description: Concentrated sunlight will excite a plasma. Characteristics of the plasma and its containment system will be assessed in terms of theoretical performance and prior terrestrial tests. After suitable control and understanding have been achieved, the plasma will be used in MHD electrical generating systems to identify their space feasibility and operating constraints. The plasma will also be assessed as the exhaust medium for thermal plasma thrusters and for MPD thrusters.

Benefit: The direct use of solar radiation to produce plasmas will enable smaller, simpler space power and propulsion systems. Plasma devices which operate at high temperature require only small radiators to reject waste heat and thus offer important system and economic advantages for future applications.

Justification: Large amounts of free but low density energy exist in space in the form of sunlight. Capture, concentration to useful levels, and control of this energy is presently accomplished with photovoltaic cells and storage batteries. Optical concentration of sunlight and the production of high-temperature and ionized gases could provide an attractive option for the future, especially for near-earth space processing requirements.

Mission Requirements and Capability: Operation and testing of these devices will require a large, high-quality solar concentrator (developed and put into operation during an earlier mission), a high-temperature thermal radiator, and diagnostic equipment both for the plasmas and for device operation. Control by on-board scientist will be required.

Space Station vs. Free Flyer: Space station will be required for this program since the research and testing require human interaction, long term operation, auxiliary equipment and electric power and a large high-quality mirror (which was developed under an earlier space station mission).

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Electronic Materials Processing

Langley Contact: Dr. R. K. Crouch or Dr. A. L. Fripp 928-3535 (FTS)

Experiment Title: Growth of Compound Semiconductor Crystals

Mission Objectives: To provide large scale facilities for the growth of compound semiconductor crystals.

Mission Description: The Materials Processing in Space (MPS) program will demonstrate the feasibility of growing compound semiconductor crystals in a low gravity environment. The growth of such crystals for uses other than scientific investigation will require larger facilities such as anticipated to be available on space station.

Benefit: Technology advancement is often limited by the lack of availability of high purity materials with high crystalline perfection. This program will help fill that need.

Justification: The MPS program is doing the scientific investigation, on the space shuttle, of the benefits of growing crystals in the low gravity environment of space. The space station will provide the capability of successful application of this knowledge by growing usable quantities of crystals.

Mission Requirements and Capability: High temperature furnaces and heat extraction will be required in excess of that available on the space shuttle.

Space Station vs. Free Flyer: Safety and low gravity requirements indicate that a free flyer may be best but complicated controls and handling may require a manned input. Tradeoff studies would have to be made.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Electronic Materials Processing   Langley Contact: Jag J. Singh

Experiment Title: Growth of Thin Single Crystal Rhodium Wafers

Mission Objectives: Develop technology for the growth of thin (500-1000 Å) perfect single crystal wafers. One specific application of interest is to develop Rh^{103} wafers for use in Pd^{103} Mossbauer gravitometry.

Mission Description: Our efforts to date have not succeeded in developing single crystal Rh^{103} wafers of sufficient perfection to permit successful Mossbauer spectrometry based on Pd^{103}-Rh^{103} transition. It is expected that an MBE growth experiment in near-zero g environment will permit strain-free crystalline growth.

Benefit: Successful detection of Mossbauer transition in Pd^{103} will permit detection of local gravitational anomalies associated with underground liquid or metallic ore bodies.

Justification: A Pd^{103} Mossbauer gravitometer will prove very useful in arial prospecting for oil and metal ores.

Mission Requirements and Capability: Mossbauer Beam Epitaxial (MBE) growth is a slow process requiring a mission of several days/weeks duration in near-zero g environment. Successful wafer growth will also require intervention of an on-board technical specialist to periodically monitor/control the wafer growth process

Space Station vs. Free Flyer: For reasons listed above, a free flyer platform will not be suitable for the projected mission.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Space Manufacturing and Processing Technology Development **Langley Contact:** Charles J. Camarda

Experiment Title: Fabrication of Lightweight Cryogenic Heat Pipes

Mission Objectives: Develop the technology necessary to manufacture and process heat pipes using cryogenic working fluids (e.g., hydrogen, nitrogen, oxygen etc.) in a zero-g environment.

Mission Description: The purpose of the mission is to investigate fabrication methods for manufacturing various types of large lightweight cryogenic heat pipes. Toward this end, several types of working fluids, heat-pipe configurations, fabrication techniques and cleaning and processing procedures should be investigated. Types of heat-pipe configurations might vary from a simple cylindrical configuration to more complex designs such as a flat plate sandwich panel or a variable conductance heat pipe. Fabrication techniques such as diffusion bonding or welding could be investigated together with cleaning, fluid charging, and sealing procedures. Several heat pipes will be fabricated and tested in space and their performance recorded. Earth testing will be impossible since the designs will be ultralightweight and not capable of containing the high internal pressures of the cryogenic working fluids at ambient temperature.

Benefit: Heat pipes may play a very large role in space as radiators for space stations or satellites or possibly in the design of thermally inert distortion free structures such as large space antennas or optical systems such as lasers or telescopes. Most of the above applications will require heat pipes using cryogenic working fluids whose structural design will be dominated by the very high internal pressures of the cryogenic fluids at room temperature. Manufacture of these heat pipes in space would result in large savings in mass.

Justification: The fabrication of large ultralightweight cryogenic heat pipes (approximately 50 ft.) will require extended use of a large, low temperature environment afforded by the space station. Also, the need for human interaction is necessary in the fabrication as well as the testing aspects of the experiment since ground testing is not feasible.

Mission Requirements and Capability: Low temperature cryogenic area necessary for fabricating heat pipes 50 feet or longer. Power necessary for welding or diffusion bonding and for testing and data collection should be at normal levels.

Space Station vs. Free Flyer: The proposed experiment needs continued human interaction during the fabrication and test processes. It is not conceivable that fabrication be done on a free flyer because of the complexity of procedures involved in the fabrication, cleaning, and processing of the heat pipes.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Space Teleoperator Systems Research Langley Contact: A. J. Meintel

Experiment Title: Manipulator Controls Technology

Mission Objectives: 1. Determine the characteristics and limitations of interactive and adaptive control technology applied to space teleoperator systems. 2. To develop a quantitative data base with which to compare and predict task performance with teleoperation and in a space suit.

Mission Description: A lightweight low-inertia dual-arm manipulator system will be attached to the space station or associated structure. The manipulator system will be controlled from a teleoperator control station in the space station, through a computer interface, using both supervisory and direct control modes.

Initially, the manipulator system will be in a space station laboratory. Tests within the laboratory will include evaluation of system response-to validate ground based models, to identify system parameters, and to develop adaptive control algorithms for zero g operations. Experiments will provide data on operator restraints, workload, mobility, and response to bilateral forces. Baseline tests will be conducted to compare task performance using the teleoperator with performance in a space suit.

In addition to tests within the space station the teleoperator system will be attached to a carrier vehicle such as TMS to develop the technology and integrated procedures required for remote operations such as construction, inspection, materials transfer, and repair.

Benefit: A teleoperation system will perform activities outside the space station (EVA) over a long time period, over long distances, with precision, without human risk, and with replinishable electrical power the only consumable. A teleoperator can capture, transport, orient, and stabilize materials and payloads needed for EVA operations.

Justification: The Shuttle RMS is the first space teleoperator. It also illustrates the handicap in development of space teleoperator technology. The RMS, like all manipulators, is a flexible, coupled, nonlinear system. The stabilization and control problems are analogous to those of other large space structures. The RMS can (and had been) mathematically modelled, but because it is designed for zero g it cannot be tested under 1g to validate its characteristics and develop control laws that will improve its response and stability. Neutral buoyancy tests would require structural changes and would have large viscous effects. A space station would provide the time to systematically validate the math models and improve the performance based on the true measured characteristics of a space-based teleoperator system.

Justification-Cont.- Also, many teleoperator systems employ bilateral force feedback because it gives the operator an indication of the forces exerted on the manipulator end effector or tool. The RMS is not a force reflecting system and the aft flight deck has limited space. The space station would have room for conventional and bilateral controllers, and the effects of forces transmitted to the operator and the restraints required for zero g could be evaluated.

Mission Requirements and Capabilities:

Mass, volume, operational envelope- All configuration dependent. TBD.

Data management, communication- Outputs of system will be monitored and some parameters recorded. Onboard data analysis capability desirable.

RF link for TV and command/feedback required for remote teleoperator control (with TMS or other free-flyer).

Crew Timeline- Crew scheduling will be necessary, but teleoperation technology studies schedule can be flexible. Operations outside space station will significantly effect crew timelines.

TECHNOLOGY DEVELOPMENT MISSION DESCRIPTION

Mission Title: Langley Contact:

Space Station Acoustics Control Technology Development D. G. Stephens

Experiment Title:

Noise and Vibration Habitability Criteria Validation

Mission Objectives:

Validate noise and vibration environment criteria for long duration manned space missions.

Mission Description:

Objective and subjective tests will be conducted to validate habitability criteria developed for the noise and vibration environment of the space station. Tests will assess the effects of the space station noise and vibration environment on hearing, speech, task performance, annoyance, and sleep of the crew. Other tests will measure and monitor the noise and vibration environment aboard the space station for comparison with predicted environments.

Benefit:

The experiments would provide confidence in the criteria for longer duration missions and will assure maximum crew utilization.

Justification:

The vibroacoustic environment of a space station will directly affect the comfort, performance and utilization of the onboard personnel. Although criteria can be developed for crew habitability, ground based tests and simulations cannot provide sustained low "g", long duration confinement or sustained exposure necessary to validate the noise and vibration criteria. Comparison of the actual environment with predictions based on expected effects of zero external acoustic radiation on the internal acoustic and vibration environment are necessary to assure the adequacy of current models.

Mission Requirements and Capability:

Minimal additional mass, volume, power or environmental constraints beyond normal crew habitability requirements are anticipated.

Space Station vs. Free Flyer:

A manned long duration mission is required.

David Ennis
Ames Research Center

ACTIVE OPTICS TECHNOLOGY

I. Mission Objectives

To provide a technology base for the operation and construction of large-aperture segmented mirrors having high surface accuracy optical figure.

II. Mission Description

The proposed mission will investigate critical technological issues germane to the use of large multi-segmented active reflectors in future space projects. Key areas of experimentation are maintenance of surface figure and segment orientation through positional accuators and control algorithms; measurement of optical image quality through wavefront sensing and laser ranging techniques; deployment, erection, and mechanical vibration control of the truss support structure for the primary mirror; and, accurate angular pointing of the antenna assembly. Since the technological readiness of the assembled reflector will be confirmed by astronomical observations, technological issues relating to infrared detectors and associated cyrogenic engineering; microwave recievers, and optical fibers will also be addressed.

III. Benefit

Due to the generic nature of the optical technology research comprising the proposed mission, the results will be applicable to several types of NASA advanced space projects. Future high-spatial resolution remote sensing of earth resources and environmental conditions will require large diameter active reflectors. An active space-optics technological base will also be required for high bit-rate microwave communication antennae used on planetary spacecraft; solar heat collecting mirrors; and space telescope systems such as LDR, the Large Deployable Reflector.

IV. Justification

The Active Optics Technology Mission will require a prolonged time exposure to the space environment. Low gravity conditions are needed to insure realistic/useful technological data as well as to investigate capillary confinement techniques used to contain cyrogenic fluids. In order to demonstrate the lifetime of positional and accuating active mirror components and to investigate the time-integrated effects of particle radiation damage of infrared detectors, the Mission should have a several year duration. Optical technology concerns specifically related to the environment of space include the thermal deformation of the mirror figure due to solar illumination; the effect of solar wind torques on reflector pointing; and the effect of a vacuum on

resin-matrix structural composites. Manned interaction will be necessary for mission operation in the following areas: deployment and initial alignment of mirror panels and back-up structure; control of subsystem experiments; and development of the astronomical observing program.

V. Mission Requirements and Capabilities

A) Orbital Parameters- Orbit altitude and inclination angle should be chosen to maximize the potential of the astronomical observations.

B) Mass, Volume, Operational Envelope- In order to allow reasonable scaling of the technological data obtained in this mission, the test mirror should be composed of several panels each 1-4 meters in diameter.

C) Power- The power requirements are dependent upon the specific details of the instruments employed.

D) Thermal Control- Thermal insulation on the rear surface of the mirror panels and a passive sunshield will be used to regulate the reflector temperature. The space station need not provide thermal control.

E) Attitude, Stabilization- A high degree of positional stability will be required in order to make possible accurate wavefront contour measurements, CCD star tracker testing, laser ranging technology evaluation, and astronomical observations.

F) Viewing- see comment on Orbital Parameters

G) Environmental Constaints- none

H,I) Data Management, Communications, Crew Timeline- TBD

J) Operations Schedule, Maintenance, Lifetime- For the reasons detailed in section IV, a several year Mission lifetime is required.

VI. Space Station vs. Free Flyer

Due to the large physical dimensions, long timescale, and diverse subsystem experiments requiring manned interaction, characteristic of this Mission, it can be argued that a space station would be the most suitable location for the mission operation.

David Ennis
Ames Research Center

CRYOGENIC LIFETIME TECHNOLOGY

I. Mission Objectives

To provide a technology base for the long-term storage of cryogenic fluids in the space environment.

II. Mission Description

The proposed mission will evaluate diverse advanced active and passive technologies ofr the maintenance of cryogenic temperatures in space on a multi-year timescale. Candidate technological areas to be investigated include, among others, the contactless operation of magnetic bearings, the passive orbital disconnect system (PODS), and the droplet radiator. A spaceborne cryogenic facility of this type will also provide an oppurtinity for technological and scientific experiments including the testing of the dimensional stability of structural materials undergoing thermal cycling and critical low-temperature physics investigations.

III. Benefit

The data obtained from the proposed mission would provide enabling technology for the Orbital Maneuvering/Transfer Vehicle propulsion systems; cyrogenic temperature propellant storage for deep planetary missions; operation of infrared detectors for remote sensing of the earth and planets and for astronomical observations; and life support and power generation systems.

IV. Justification

In order to properly investigate surface tension and thermal interaction effects involved in cryogenic fluid transfer; to evaluate advanced cyrogencic vent systems; and to conduct measurements of the superfluid lambda-point transition of liquid Helium with a heretofore unattainable precision; a stable, low-gravity, long-duration, space station is required. The proposed cryogenic liquid storage facility must undergo a technical demonstration in the high-energy particle flux encountered in earth orbit. Of specific concern is the cosmic ray and thermal degradation of reflective cooling coatings and the flow stability of the liquid stream in oil-drop radiator technologies. Finally, manned interaction wtih the cryogenic strorage facility will allow real-time control/planning of the subsytem investigaions and technologies as well as providing the requisite maintenance and repair.

V. Mission Requirements and Capabilities

A) Orbital Parameters- None

B) Mass, Volume, and Operational Envelope- TBD. It is anticipated that the stored cryogen and its associated refrigeration apparatus will occupy a large volume due to the requirement of a multiyear lifetime.

C) Power- Power requirements are specific to the individual experiments and subsystem technologies.

D) Thermal Control- Thermal control will be a critical feature inherent to the cryogenic storage facility and should not be a provision of the space station.

E) Attitude, Stabilization- Sucessful operation of the cryogenic physics experiments will require low, gitter-free, gravitational acceleration levels- numerical values: TBD. High positional stability is also needed to insure operability of laser interferometric techniques for the measurement of microcracking due to thermal stresses in resin-based structural metrology.

F) Viewing Requirements- none

G) Environmental Constraints- TBD

H,I) Data Management, Communications, Crew Timeline- Manned interaction for Data/Communications management is required (see Section IV). Detailed crew timeline-TBD.

J) Operations Schedule, Maintenance, Lifetime- Specification of the hold time for the cryogenic-storage facility is on the order of five years.

VI. Space Station vs. Free Flyer

Although a trade-off analysis is required in order to ascertain the suitability of the proposed mission as a space station experiment, it should be pointed out that the large volume, long time duration, and stable low-g environment required for mission operation are characteristic of space station specifications.

David Ennis
Ames Research Center

MATERIALS AND COATING TECHNOLOGY

I. Mission Objective

To provide a technology base for the production of structural and insulating materials, and optical, thermal, and absorbing surface coatings capable of sustained performance in the space environment.

II. Mission Description

Data will be obtained on the effect of given characteristics of the space environment on critical physical properities of materials and coatings anticipated for use in future space projects. Specific areas of investigation include the degradation of the reflectivity of mirror/antenna metallic coatings as well as the decrease in the absorbtivity of low-scatter optical black surfaces when exposed to solar illumination and solar wind/cosmic ray high energy particle fluxes. Meteoroid venting of the interstitial spaces of thermal insulating materials; decreases in the Young's Modulus of resin-matrix structural composite materials due to cosmic-ray damage and vacuum effects; and particle contamination of the thermal-control coatings applied to heat pipes are also technological concerns. The developed Mission facility will also have the capbility for investigations in the area of space polymer chemistry.

III. Benefit

Since the proposed investigation is involved with common materials and coatings used in varied components of future space missions, the resulting data will be instrumental in developing the enabling technology associated with same missions.

IV. Justification

Based on the Mission specifications, it is apparent that the fundamental requirement for mission operation is long-term exposure to the particle and radiation fluxes only obtained the space vacuum environment. A multi-year Mission lifetime will allow the establishment of time-integrated cumulative effects on the measured physical parameters. Such a procedure represents a substantial improvement over the time-accelerated ground-based testing. Due to the large number of material/coating subsystems comprising the total mission, manned interaction is needed for control and data acquistion.

V. Mission Requirements and Capabilites

A) Orbital Parameters- Orbit altitude and inclination angle will be chosen to allow the requsite solar illumination and

high-energy particle flow rate.

B) Mass, Volume, Operational Envelope- Due to the large dimensions anticipated for the surface coatings used in future space project, the area of the samples investigated in the proposed Mission must be on the order of many square meters.

C) Power- The power requirements will depend upon the exact characteristics of the subsystem technology and measurement devices employed.

D) Thermal Control- TBD

E) Attitude, Stabilization- Since optical spectrometers of high positional sensitivity will be utilized in the reflectivity and absorbtivity measurements, a high degree of stability will be required of the space station.

F) Viewing- See comment on Orbital Parameters.

G) Environmental Constraints- none.

H,I,J) Data Management, Communications, Crew Timeline, Operations Schedule, Maintenance, Lifetime- TBD

VI. Space Station vs. Free Flyer

Due to the large physical dimensions, long timescale, and diverse subsystem experiments requiring manned interaction, characteristic of this Mission, it can be argued that a space station would be the most suitable location for the mission operation.

David Ennis
Ames Research Center

SPACE COMPONENT LIFETIME TECHNOLOGY

I. Mission Objective

To provide a technology base for the development of diverse hardware components for which a multi-year operational lifetime under space conditions is specified.

II. Mission Description

The propsed mission would characterise the performance lifetime of critical components selected form varied space technologies. Components requiring evaluation in the space environment include primary propulsion systems; solar cell and chemical battery power units; space qualified solid film lubricants; laser and conventional spin gyros; and microwave amplifier cathodes.

III. Benefit

The proposed technology evaluation of spaceborne power units, propulsion systems, and navigational devices will have direct applicability to NASA deep planetary missions. In general, the component lifetime demonstrations achieved through the proposed Mission would increase the probability for sucess of advanced space projects.

IV. Justification

It is clear from the definition of the Mission objectives that the requiste component technology investigation can only occur on a long duration space laboratory. For proper solar cell technology evaluation, both the orbital solar illumination and high energy particle flux are required. In additon to conversion efficiency, a major technological tradeoff between silicon and gallium arsnide solar cells is the ability to withstand radiation damage. In order to perform the in situ annealing and repair of degraded solar cells, a manned presence is required.

V. Mission Requirements and Capabilities

A) Orbital Parameters- The Mission orbit should insure the requisite photon and high energy particle flux.

B) Mass, Volume, and Operational Envelope- TBD

C) Power- Instrument specfic.

D) Thermal Control- TBD

E) Attitude, Stabilization- Verification and measurement of

gryoscopic performance requires high space station angular stability.

F) Viewing - See comment A) above.

G) Environmental Constraints- none.

H,I) Data Management, Communications, Crew Lifetime- TBD

J) Operations Schedule, Maintenance, Lifetime- The components to be tested have nominal space lifetimes between five and ten years.

VI. Space Station vs. Free Flyer

Although a detailed trade-off analysis is required it should be pointed out that the critical Mission specifications are characteristic of anticipated space station performance.

William Wales
Marshall Space Flight Center

LARGE SPACE STRUCTURE TECHNOLOGY

I. MISSION OBJECTIVES

To provide a technology base for systems, in the large structures class, requiring construction and/or assembly utilizing support from a manned orbital station. These technology development mission(s) will also utilize ground facilities and orbiter tests for small, short duration, segregated experiments.

II. MISSION DESCRIPTION

The mission proposed will provide the technology required for the construction and assembly of large structural components and systems while attached to and supported from a manned space station. Key issues associated with this technology development are: support equipment interfaces; man, man-machine, and machine functions; develop crew skill requirements and space station operational interface requirements. Robotic constructions will also be considered in developing this technology.

The technology required to construct and assemble large structures on-orbit will require ground facilities and orbiter tests utilizing small experiments or scaled tests. The larger and longer duration tests will involve the manned space station. In the large space structures technology, the crew and space station equipment play a vital role.

III. BENEFIT

Large Space Structures can be fabricated and/or assembled on-orbit to provide larger and lighter, and possibly cheaper, space structures.

IV. JUSTIFICATION

Large space structures such as communication antenna or optical devices are required in orbit to improve the quality of data. The most effective means of providing this capability is through assembly in orbit, which allows the structural system and its components to be much larger and much lighter. These technologies can be developed more effectively in a zero-gravity space environment.

V. MISSION REQUIREMENTS AND CAPABILITIES

UNDER STUDY

VI. SPACE STATION VS. FREE FLYER

This technology development mission requires the support from a manned space facility where subsystems support and crew skills are available. Small functional experiments or tests will be developed from ground facilities or utilizing the orbiter for short duration tests.

William Wales
Marshall Space Flight Center

SATELLITE SERVICING TECHNOLOGY

I. MISSION OBJECTIVES

To provide the technology required to serve free-flying spacecraft/satellite at an orbital support facility. The servicing of satellites includes not only periodic support but repair and checkout of defective satellite systems. The retrieval and redeployment may be a function of the space station; however, it is not a part of this technology development mission.

II. MISSION DESCRIPTION

The proposed mission(s) are required to develop that technology needed for servicing satellites in space at a manned facility and/or remotely from the manned facility. The issues of major concern are: subsystems module replacement and checkout, grapple/attachment techniques, fluid transfer, remote servicing/checkout, and orbital assembly of satellites (limited). The technology development mission(s) selected will represent a cross section of those satellite functions and services required from the support facility.

Due to the magnitude of this mission(s) and possibly the varied services required, a large number of experiments may be required and developed over a long period of time utilizing the space station.

III. BENEFIT

The development of this technology will enable satellites to remain operational for much longer periods of time. Satellites would not be required to be designed for very long lifetime since the service capability is available. Systems redundancy and mass could be reduced. In essence, the satellite could be built cheaper and have a longer life through the on-orbit servicing capability.

IV. JUSTIFICATION

Experiments relative to the attaching and servicing of satellites require these activities be performed in the operational environment. Handling equipment and remote servicing systems and fluid handling system can be developed more effectively in the zero-gravity environment of space.

V. MISSION REQUIREMENTS

UNDER STUDY

VI. SPACE STATION VS. FREE FLYER

The technology development mission for the satellite servicing technology should be conducted utilizing the space station facility. These experiments/tests will require man-in-the-loop either directly or remotely and cannot be automated economically.

William Wales
Marshall Space Flight Center

OTV SERVICING TECHNOLOGY

I. MISSION OBJECTIVES

To provide the technology required to maintain an Orbital Transfer Vehicle (OTV) on-orbit between flights. Early implified experiments in the OTV technology evolution could be performed in ground facilities or from the Orbiter. However, the more complex, longer duration tests/experiments will require the support of the space station.

II. MISSION DESCRIPTION

The proposed mission(s) are required to develop the technology needed for servicing the Orbital Transfer Vehicle system and maintaining it from an orbit base. Those issues of major concern are: the refueling, gauging and preservation of the OTV propellants; the maintenance, replacement and checkout of avionics components; the servicing and replacement of propulsion system components; installation of any aerodynamic braking or aeromaneuvering system; and the integration and checkout of the OTV with another stage, single or multiple type payloads; and/or a manned crew transfer module.

Due to the magnitude of this mission(s) a large number of experiments will be required and developed over a long period of time utilizing the manned space station.

III. BENEFIT

The development of this technology will enable the OTV to remain on-orbit for extended periods of time, thus allowing the full shuttle capability to be devoted to other payloads. The technology required to develop the space-based OTV will have significant impacts on other programs utilizing the space station's servicing, maintenance, and operational facilities.

IV. JUSTIFICATION

Experiments relative to the overall management of propellants require long duration tests in a zero-gravity space environment. Storage tests can best be accomplished in a natural space environment. OTV and payload and added stage handling will utilize space station handling equipment. These tests are essential to establish the commonality of equipment on the station to support multiple programs.

V. MISSION REQUIREMENTS

UNDER STUDY

VI. SPACE STATION VS. FREE FLYER

The technology required to develop the OTV servicing capability requires man-involvement and is not suited for the free-flyer concept.

JSC/A. Potter

TETHER DYNAMICS TECHNOLOGY

I. Mission Objective

To provide a technology base for applications of long tethers attached to orbiting spacecraft.

II. Mission description

The missions proposed will provide the technology needed for successful deployment, operation, and retrieval of long tethers from orbiting spacecraft and the use of electrodynamic forces on conducting tethers for control of the tether and generation of thrust and drag. An experimental tether about 100 meters long will be deployed, and its dynamic response to mechanical and electrodynamic forces will be measured and compared with theory.

III. Benefit

The ability to deploy, control, and retrieve long tethers from an orbiting spacecraft in a safe and successful manner would permit several useful applications.

IV. Justification

Long tether systems have been proposed for research on the atmosphere and ionosphere, VLF antennas, and electrodynamic thrust and drag control. Basic engineering research on the control and stability of long tethers in orbit is needed before these applications can be realized.

V. Mission Requirements and Capabilities

A) Orbital Parameters - none

B) Mass and volume and operational envelope - Volume and mass are initially estimated at 250kg and 100 cu ft. Operational envelope outside the spacecraft is of the order of 100 meters long, 10 meters diameter.

C) Power - The power requirement for this experiment is of the order of

1KW (to operate the electrodynamic aspects of the experiment).

D) Thermal control - Controlled to earth-based laboratory values for equipment inside the space station.

E) Attitude Stabilization - Constant attitude during initial experiment periods. Controlled attitude changes will be used later to study dynamics of the tether.

F) Viewing - Deployed tether must be visible from the spacecraft to monitor its movements.

G) Environmental Constraints - No significant constraints.

H,I) Data Management, Communications, Crew Timeline - Experiment is intended to be man-operated in real time by trained payload specialists who will collect data for later analysis.

VI. Space Station vs. Free Flyer

Manned operation requires space station.

JSC/R. Hill

EARTH OBSERVING TECHNIQUE DEVELOPMENT

I. MISSION OBJECTIVES

To develop optimum earth observing technique development leading to the ability to rapidly communicate pertinent information to ground users for near real-time reaction.

II. MISSION DESCRIPTION

A manned earth observatory would provide an opportunity to develop optimum observing/communications techniques to relay information to ground investigators in near real-time. The role of the onboard observer could be evaluated as applied to a wide variety of earth observing problems. The results of these evaluations could lead to concepts for man's involvement (or non-involvement) in earth observations in an operational mode. This would include development and evaluation of techniques for detecting and monitoring episodic events, such as volcanoes, earthquakes, tidal waves, severe storms, etc.

III. BENEFIT

Man's involvement will permit economies in data collection and reduction that will lead to more rapid development of a capability to remotely sense transient phenomena, such as ocean features and currents, and to relay pertinent information to the surface for operational use. Users of ocean surface information include the U.S. Navy, the marine transportation industry, the offshore drilling industry, the fishing industry, and oceanographers. Users of data on episodic events include scientists and government, disaster relief organizations and the general population.

IV. JUSTIFICATION

The availability of man to detect transient phenomena, to screen data, and to communicate with experts on the ground will result in rapid development of techniques to make effective use of remotely sensed data. The use of a manned earth observatory in this manner will also provide an experience level to establish the role of manned participation in the further application of remote sensing to these problems.

V. MISSION REQUIREMENTS AND CAPABILITIES

A. Orbital Parameters - A near polar orbit inclination is desirable for many operational remote sensing tasks; however, sensor and technique development can be readily accomplished from inclinations as low as 28.5 degrees. Orbital altitudes of 150 - 500 miles are acceptable.

B. Mass, Volume, -- Mass and volume for a manned earth observatory are yet to be determined, but an estimate of volume would be one or two times the Spacelab volume on Space Shuttle.

C. Power - The power requirements will depend on the instrument complement, but can be assumed to include high power consumption instruments such as synthetic aperture radar.

D. Thermal Control - Thermal control will be required to maintain a shirtsleeve laboratory environment. Heat dissipation consistent with power requirements plus thermal cooling for detector arrays will be required.

E. Attitude, Stabilization - The Manned Earth Observatory will require an earth looking attitude such as could be obtained by gravity gradient stabilization of the space station. Since pointable sensors are envisaged, some large amount of wobble about the local vertical (such as 10 degrees) can be tolerated. Stability should be commensurate with the capability of an image motion compensation system.

F. Viewing - An earth viewing capability, aided by a gimballed, zoom optical system, is required.

G. Environmental Constraints - A "clean" outside environment must be maintained to insure acceptable earth viewing conditions. Conditions commensurate with those required around the Shuttle during Large Format Camera operation should suffice.

H. I. Data Management, Communications, Crew Timeline - The Manned Earth Observatory will require the full time of at least one observing specialist. Data management can be aided by observer selection of spectral bands to be recorded, by onboard data screening and selective transmission to ground. Data rates to ground can be rather high, as a scanner instrument such as the Thematic Mapper on Landsat 4 generates data at the rate of ~80 mega bits/second.

J. Operations Schedule, Maintenance, Lifetime - TBD

VI. SPACE STATION VS. FREE FLYER

The Manned Earth Observatory would be initially considered as a research and development laboratory, and would be designed to take maximum advantage of man's capability for enhancing sensor and scientific research and observation technique development. The results of this R&D effort will presumably lead to operational sensors on free-flyers and man tended platforms. In addition, man's role in operational remote sensing of the earth will be empiracally determined.

JSC/R. Hill

EARTH OBSERVATION SENSOR DEFINITION

I. MISSION OBJECTIVES

To develop optimum earth observing instrumentation and observing parameters definition for use on operational earth observing platforms.

II. MISSION DESCRIPTION

The proposed earth observatory will make the maximum use of man in experimentation with a variety of prototype earth observing instrumentation. Studies of candidate spectral and spatial resolution; studies of optimum sun elevations and viewing angles and studies of various polarizations versus particular ground features of interest are examples of areas where the technology could be improved for use on later manned or unmanned operational remote sensing satellites.

III. BENEFIT

Would provide an easily accessible test bed where man could readily interchange detector arrays, filters, and instruments where man could fine tune such things as pointing and image motion compensation to ensure that optimum data was recorded over the specific test site of interest.

IV. JUSTIFICATION

The availability of a test bed for prototype instrumentation and man-aided pointing and tracking capabilities will help ensure that operational satellites contain optimum instrumentation and are launched in orbits most suitable for the operational remote sensing task to be accomplished.

V. MISSION REQUIREMENTS AND CAPABILITIES

A. Orbital Parameters - A near polar orbit inclination is desirable for many operational remote sensing tasks; however, sensor and technique development can be readily accomplished from inclinations as low as 28.5 degrees. Orbital altitudes of 150 - 500 miles are acceptable.

B. Mass, Volume, -- Mass and volume for a manned earth observatory are yet to be determined, but an estimate of volume would be one or two times the Spacelab volume on Space Shuttle.

C. Power - The power requirements will depend on the instrument complement, but can be assumed to include high power consumption instruments such as synthetic aperture radar.

D. Thermal Control - Thermal control will be required to maintain a shirtsleeve laboratory environment. Heat dissipation consistent with power requirements plus thermal cooling for detector arrays will be required.

E. Attitude, Stabilization - The Manned Earth Observatory will require an earth looking attitude such as could be obtained by gravity gradient stabilization of the space station. Since pointable sensors are envisaged, some large amount of wobble about the local vertical (such as 10 degrees) can be tolerated. Stability should be commensurate with the capability of an image motion compensation system.

F. Viewing - An earth viewing capability, aided by a gimballed, zoom optical system, is required.

G. Environmental Constraints - A "clean" outside environment must be maintained to insure acceptable earth viewing conditions. Conditions commensurate with those required around the Shuttle during Large Format Camera operation should suffice.

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J. Operations Schedule, Maintenance, Lifetime - TBD

VI. SPACE STATION VS. FREE FLYER

The Manned Earth Observatory would be initially considered as a research and development laboratory, and would be designed to take maximum advantage of man's capability for enhancing sensor and scientific research and observation technique development. The results of this R&D effort will presumably lead to operational sensors on free-flyers and man tended platforms. In addition, man's role in operational remote sensing of the earth will be empiracally determined.

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JSC/R. Hill

EARTH FEATURE IDENTIFICATION - ANALYSIS TECHNIQUES AND AUTOMATED SYSTEMS DEFINITION

I. MISSION OBJECTIVES

To use a manned earth observatory to locate and study transient phenomena and to support remote sensing research with the goal of defining analysis techniques and systems for use in remote sensing applications.

II. MISSION DESCRIPTION

Basic research and scientific studies - Man could play an important role in orienting instruments to observe and record phenomena that are transitory in either time or location. By using real-time displays he could play an important role in selecting the best instrumentation to record what he was observing. Man could selectively transmit appropriate data to the ground for consultation with ground based experts. An onboard observer could also play an important role in fine tuning the pointing angles and image motion compensation to acquire data from ground sites of known location. This would be particularly important where instruments with narrow fields of view or high spatial resolution were involved.

III. BENEFIT

The manned observer can detect phenomena of interest, select appropriate spectral bands, and screen data before transmission to the ground, thus effecting tremendous economies in data collection and transmission. Man can also fine-tune instrument pointing and tracking, resulting in improved data quality.

IV. JUSTIFICATION

Given the tremendous data rates associated with many earth observing instruments, such as multispectral imagers and synthetic aperture radars, controlled data acquisition, preprocessing, and transmission become valuable tools in compressing the time needed to perform research tasks. This should lead to earlier understanding of the nature of transient phenomena and how to best observe them on a continuing basis with operational remote sensing spacecraft.

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OF POOR QUALITY

V. MISSION REQUIREMENTS AND CAPABILITIES

A. Orbital Parameters - A near polar orbit inclination is desirable for many operational remote sensing tasks; however, sensor and technique development can be readily accomplished from inclinations as low as 28.5 degrees. Orbital altitudes of 150 - 500 miles are acceptable.

B. Mass, Volume, -- Mass and volume for a manned earth observatory are yet to be determined, but an estimate of volume would be one or two times the Spacelab volume on Space Shuttle.

C. Power - The power requirements will depend on the instrument complement, but can be assumed to include high power consumption instruments such as synthetic aperture radar.

D. Thermal Control - Thermal control will be required to maintain a shirtsleeve laboratory environment. Heat dissipation consistent with power requirements plus thermal cooling for detector arrays will be required.

E. Attitude, Stabilization - The Manned Earth Observatory will require an earth looking attitude such as could be obtained by gravity gradient stabilization of the space station. Since pointable sensors are envisaged, some large amount of wobble about the local vertical (such as 10 degrees) can be tolerated. Stability should be commensurate with the capability of an image motion compensation system.

F. Viewing - An earth viewing capability, aided by a gimballed, zoom optical system, is required.

G. Environmental Constraints - A "clean" outside environment must be maintained to insure acceptable earth viewing conditions. Conditions commensurate with those required around the Shuttle during Large Format Camera operation should suffice.

H. I. Data Management, Communications, Crew Timeline - The Manned Earth Observatory will require the full time of at least one observing specialist. Data management can be aided by observer selection of spectral bands to be recorded, by onboard data screening and selective transmission to ground. Data rates to ground can be rather high, as a scanner instrument such as the Thematic Mapper on Landsat 4 generates data at the rate of ~80 mega bits/second.

J. Operatiors Schedule, Maintenance, Lifetime - TBD

JSC/K. Demel

MATERIALS PROCESSING TECHNOLOGY - PROCESS AND TECHNIQUE ANALYSIS
- SYSTEM AND PROCEDURE DEVELOPMENT

I. MISSION OBJECTIVES

To provide a scientific and technological base for optimizing the man machine mix for expeditiously transforming materials processing phenomena in low g environment into commercially viable product lines.

II. MISSION DESCRIPTION

The missions proposed will provide the laboratory environment for developing the optimal utilization of research and development capabilities of materials scientists/developers in space processing. Key issues regarding man's roles in research and development in the space environment will be resolved. For example, much of the current materials processing in space (MPS) has designed the role of man out of the experimental process, leading to single shot experiments, earth recovery and analysis of each sample prepared and relaunch for experiment repeat. This scenario leads to long development times; i.e., orders of magnitude longer than similar material process development on earth.

Specific laboratory equipment, facilities, manning skill mix, and testing instrumentation must be identified so that commercialization of materials available only from zero g can progress at economically favorable rates. The hypothesis of this work is that optimal space research development and commercial process development will contain many of the man directly in the loop functions that are commonplace in earthbound laboratories.

Because of the many (uncountable) degrees of freedom possible in incorporating the human in the loop research and development potential (heavily exploited in earth labs) this mission would greatly benefit from space laboratory protocol and procedures development within an MPS laboratory connected to the space station incorporating necessary acceleration isolation.

III. BENEFIT

Use of and development of MPS discipline scientists and engineers in the commercialization of metallurgicals, biologicals, glasses, crystals, etc., can be expected to provide commercialization of manufacture of unique high value materials not posible on earth with an economically attractive return on investment.

IV. JUSTIFICATION

It is essential for commercialization of MPS that the R&D technologies have continuous man in the loop involvement with a prospective material to enable much more rapid repeat of factorial experiments. Figure 1 indicates a Mode I and Mode II lab process flow. Figure 2 indicates the acceleration of the development of commercial processes that could be available with man in the loop in Mode II. If a product is to be a success commercially, it must become available to the market when the market exists, not a generation later.

V. MISSION REQUIREMENTS AND CAPABILITIES

A. Orbital Parameters - None

B. Mass, volume, operational envelope - Mass requirements are uncertain but an estimated volume commensurate with small compact efficient materials processing laboratories on earth may be required for a development laboratory. A key element to any manned operating laboratory is space.

C. Power - The power requirements are experiment peculiar. However, it can be anticipated that both AC and DC power as normally available in earth-bound laboratories will be required.

D. Thermal Control - Thermal control for the individual experiments will be experiment peculiar and should not be a requirement of the Space Station. Thermal control of the laboratory, however, should be available and operational to earth based laboratory values. This issue may be related to environmental control.

E. Attitude, Stabilization - The Laboratory Concept must operate in a gravitational environment which must be capable of providing controlled low acceleration levels. An ancillary propulsion system will be required to provide this control and is considered a separate technology mission.

F. Viewing - No requirements except for scientist psychological health.

G. Environmental Constraints - All combustion related technology experiments will probably require venting to release products of combustion.

H,I. Data Management, Communications, Crew Timeline - The MPS Technology Development Laboratory will need to be manned to perform technology experiments in real-time. Payload Specialists/Disciplinary scientists will need to be trained to operate and upkeep data management system, conduct tests, analyze data, and transmit data back to earth for subsequent analysis. Crew timelines should be scheduled to eliminate undesirable g-jitter disturbances to experiments.

J. Operations Schedule, Maintenance, Lifetime - TBD

VI. SPACE STATION VS. FREE FLYER

The technology experiments identified have both safety and acceleration control requirements that may require trade studies between Space Station and a tethered element. In either case, this laboratory should be capable of providing controlled low levels of Reduced Gravity. The laboratory concept is envisioned to provide adequate space, power, thermal control, and basic experimental services such as supply air, etc. Experiment peculiar instrumentation would be a part of this laboratory as would generalized test equipment; i.e., optical/electron microscopes machine tooling, sample preparation equipment, etc.

VI. SPACE STATION VS. FREE FLYER

The Manned Earth Observatory would be initially considered as a research and development laboratory, and would be designed to take maximum advantage of man's capability for enhancing sensor and scientific research and observation technique development. The results of this R&D effort will presumably lead to operational sensors on free-flyers and man tended platforms. In addition, man's role in operational remote sensing of the earth will be empiracally determined.

PROCESS DEVELOPMENTS

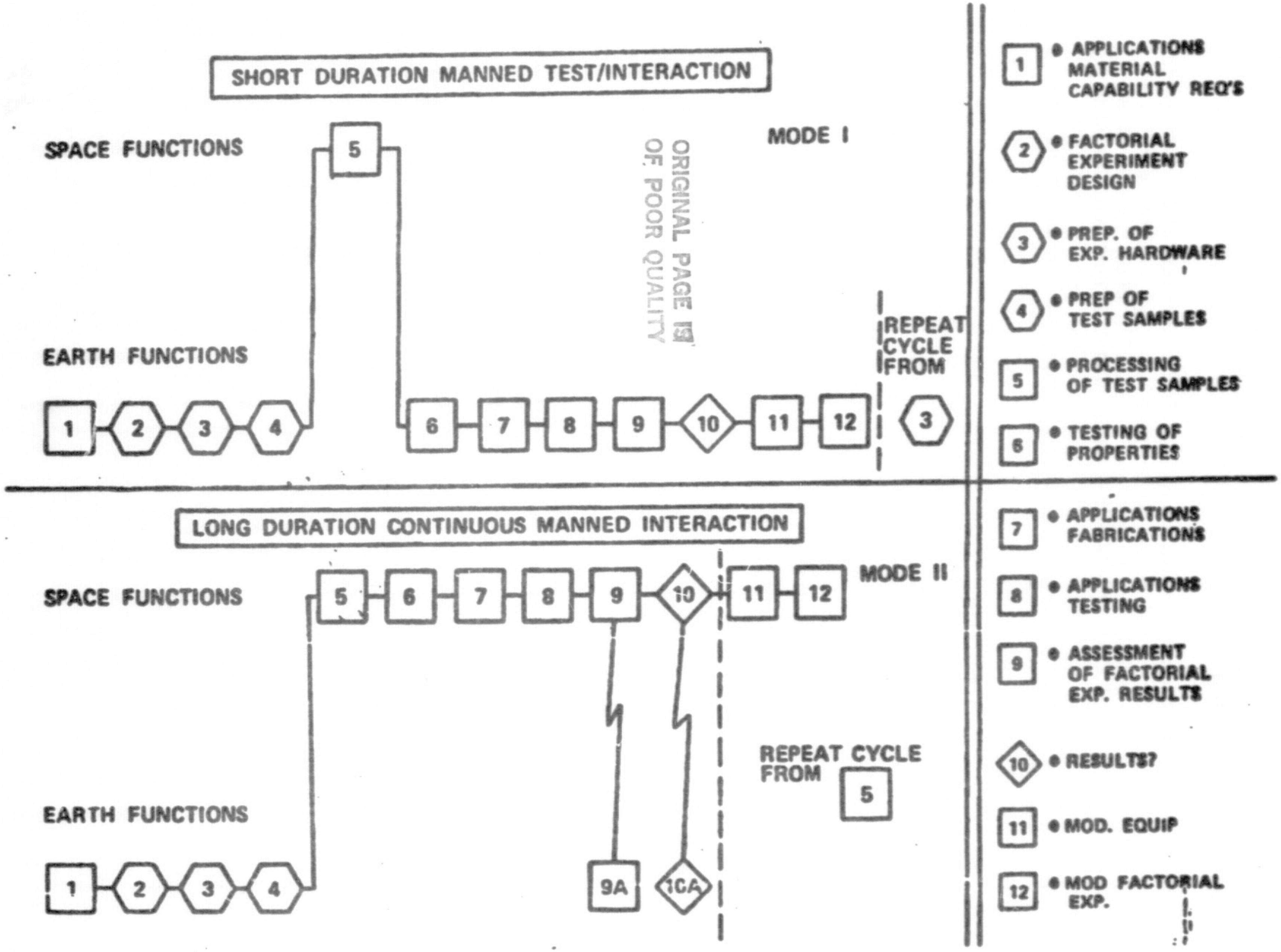

FIGURE 1

82-L1017

PROCESS DEVELOPMENT CYCLE COMPRESSION

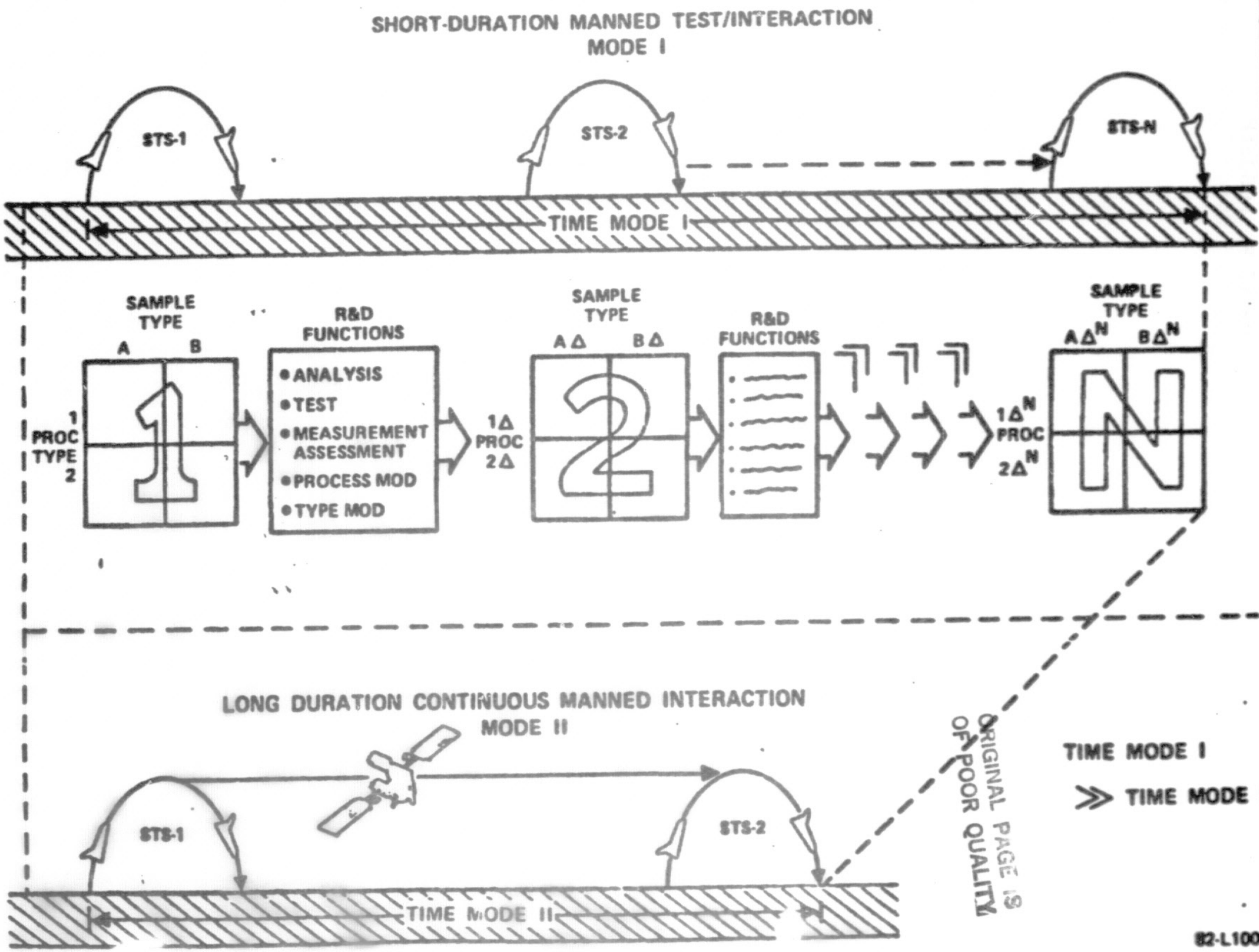

FIGURE 2

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David H. Suddeth
Goddard Space Flight Center

ELECTROPHORESIS SEPARATION OF MEDICAL MATERIALS TECHNOLOGY

I. Mission Objectives

To provide technology development and demonstration of improved methods of separating and purifying biological, medical and other types of materials under conditions of very low (milli-g) gravity.

II. Mission Description

This mission will provide improvement and demonstration of the apparatus and techniques for separation and purification of mixed materials of very similar nature by the process of electrophoresis. This process basically consists of injecting the mixture to be separated through one tube into a confining "cell", then continuously flowing it for a long distance between and parallel with long, separated electrodes that have a large voltage difference. each different type of particle in the mixture carries a different charge, characteristic of its type. this difference in charge causes each type of particle to move at its own specific rate toward one of the electrodes. the continuous flow thus soon produces separate streams of single-type particles. the result is that a mixture injected at one end of the electrodes has separated into distinct streams of each individual type of material by the time it reaches the other end of the electrodes. these discrete streams can be separately removed by individual outlet pipes. without gravity there is no sedimentation, nor thermal turbulence. this allows much greater material concentration and higher electrode currents.

Further experiments on separation methods can be done: with electrode shapes, separations and voltages; with cell sizes and shapes; with injection and removal techniques; and with many other subtle factors. this mission can greatly benefit from these experiments being done in a manned space station laboratory, where immediate observation of the results of careful, controlled changes of conditions is possible.

III. Benefit

Further careful technology experiments in the Space Station on electrophoresis separation methods can improve greatly the rate of production and the purity of separation. Many medicines and biological materials require careful separation to extreme purities to be safe or effective. On Earth, such separation can often be done only by use of electrophoresis, but even then only slowly, or not at all. In space, electrophoresis separation can do things that are impossible on Earth. It can produce extremely valuable pure materials that can be gotten in no other way. These materials are directly applicable for medical experimentation and for making medicines needed by millions of people.

IV. Justification

It has been already been demonstrated that electrophoresis separation

techniques used in orbit can separate and purify mixed materials with far greater speed, and to much higher purities than can be achieved on earth. Furthur experimentation aboard the Space Station in milli-g conditions, under direct, manned control will allow much further improvement.

V. Mission Requirements & Capabilities

A) Orbital Parameters - none

B) Mass, Volume, Operational Envelope - TBD. But an estimated volume of 100 cu ft and 1,000 lb should be adequate.

C) Power - A maximum of 1,000 watts is needed for several hours each day.

D) Thermal Control - Medical materials generally need to be kept cool as possible; just above freezing. All the electrical power absorbed in the electrophoresis separation cells must be removed as heat. The laboratory space itself should be kept near Earth-based levels.

E) Attitude, Stabilization - Attitude is not important. However, good stabilization of the laboratory is needed to maintain the necessary milli-g conditions.

F) Viewing - No requirements.

G) Environmental Constraints - Electrophoresis separation systems will probably require periodic venting to space vacuum of several pounds of water or other carrier fluid.

H & I) Data Management, Communications & Crew Timeline - The Space Station Technology Development Laboratory Will need to be manned, to perform experiments in real time. Payload Specialists will need to be trained to conduct experiments, operate data management systems and transmit data back to Earth for subsequent analysis. Crew timelines must be scheduled to eliminate intolerable levels of g-jitter disturbances to experiments.

J) Operations Schedule, Maintenance, Lifetime - TBD.

VI. Space Station VS. Free Flyer

These electrophoresis separation technology experiments are ones that can only be carried out with effective speed and cost in a manned space station laboratory. The envisioned concept of this lab is that it would provide the necessary services that an Earth lab would, except with milli-g conditions.

David H. Suddeth, Luther W. Slifer
Goddard Space Flight Center

LOW COST MODULAR SOLAR PANEL TECHNOLOGY

I. Mission Objectives

To provide the technology development and demonstration of spacecraft solar panels that embody features that allow them to be low cost, but nearly as long-lasting and efficient as current panels. The solar panels would incorporate modular design features to allow easy replacement of malfunctioning sections.

II. Mission Description

This mission would provide testing and demonstration of the technology for design and manufacture of low cost solar panels. Their costs would be greatly reduced by the use of design features suitable for space, but with application of commercial standards used for the production of reliable earth-based solar panels. The Space Station makes possible the continuous, long-term test in parallel of several candidate solar panel and power system designs, in real conditions. It makes available the space vacuum, the orbital radiation environment and the thermal cycling of continuous, frequent orbital eclipses. The thermal cycling that solar panels must endure is one of the most important and least understood causes of solar panel failure. This mission would allow us to understand the causes of these failures.

III. Benefit

Since the cost of solar arrays is a major factor in the overall cost of space systems, the major benefit would come from lowered solar panel costs. Based on the estimates of a solar panel manufacturer, the costs might be reduced by a factor of approximately three. The modular design would allow flexibility of configuration and easy replacement.

IV. Justification

While manufacturing to commercial standards implies lower proven life expectation for individual panels, their usability would not be seriously impaired if they are designed in modular sections that are intended to allow individual service and replacement by astronauts. The capability to replace a panel if it fails after several years, instead of having to make certain that it will last ten years or longer, is the major force to reduce the overall cost of solar panel systems. Commercial acceptance standards may imply lower efficiency solar cells, but any reduction of efficiency should be acceptable, even if a somewhat larger area is required, because of the greatly reduced procurement cost. The Space Station system allows continuous observation and test of candidate panels and their immediate, easy replacement by the astronauts if they go bad.

V. Mission Requirements & Capabilities

A) Orbital Parameters - None.

B) Mass, Volume, Operational Envelope - TBD, but ten pounds and a few square feet per test panel system, including its controls, is reasonable.

C) Power - These panels should produce most of their own power.

D) Thermal Control - Included as part of the test panel system.

E) Attitude, Stabilization - Solar panels should generally point within 30 degrees of the sun line; closer for testing of maximum output.

F) Viewing - Must view the Sun.

G) Environmental Constraints - TBD.

H) Data Management, Communications - Since this is long term testing, a very small data rate is expected.

I) Crew Timeline - TBD, but very little time should be needed.

J) Operations Schedule, Maintenance, Lifetime - TBD.

VI. Space Station VS. Free Flyer

Low cost types of solar panels will ultimately be used on free flyers, but they would first be required to meet established requirements during Space Station tests before they are installed on any free flyer, so its reliability would not be compromised.

David H. Suddeth, Gary P. Barnha
Jack Evans
Goddard Space Flight Center

GEODESIC SPHERICAL STRUCTURES TECHNOLOGY

I. Mission Objectives

To develop the technology for new, self-supporting, stable and highly rigid structures for spacecraft and space systems based on geodesic design principles.

II. Mission Description

This mission can provide the technology base required to build and utilize geodesic structures with high rigidity, expandibility and reusability in space environments. An example of geodesic structure is a 22 ft diameter "sphere" constructed from 20 equilateral triangle components, all of which have the same size and shape with a side length of 12 ft. The triangular components could easily fit into the space shuttle bay with all desired instruments and equipment attached inside their periphery. The components can then be assembled on-orbit as desired. When necessary, the triangles can be removed to repair or replace their instruments. The structure can also be disassembled for use in the construction of larger geodesic spheres, if needed. Such technologies are a natural extension of modularization and standard interface systems. The ability of these structures to perform as stable, rigid platforms for high resolution instruments requiring great stability in the space environment should exceed that of structures now available.

III. Benefit

Technology experiments on geodesic structures can result in a whole new generation of structural systems that meet all the basic requirements of space structures, including increased rigidity, yet also provide far greater design scope to the mission planner. Geodesic structures are comprised of only a few basic structural elements that are duplicated as required to produce a structure of desired size. The structural elements can be further sub-divided to provide stable instrumentation mounting points and better servicing characteristics. Overall, geodesic structures can have minimum mass to volume ratio, good thermal control, minimum launch volume, extreme ease of assembly from a few standard parts, high reusability, expandability and maximum mission versatility.

IV. Justification

Many space systems require structures that are a tradeoff between minimum launch weight and volume and maximum on orbit rigidity. Geodesic structures of both the bolted member and the tension type can maximize all three together. A space station provides an ideal environment for assembly, testing and modification of these advanced structural systems. These structures technologies can open up many opportunities, by making currently defined types of missions more economical and making new missions achievable, that are not now possible.

V. Mission Requirements

A) Orbital Parameters - None

B) Mass, Volume & Operational Envelope - TBD but they are a direct function of the scale of the experiments conducted.

C) Power - The power available from the baseline Space Station system can meet any power requirements of the structural assembly and testing.

D) Thermal Control - Experiment peculiar, but controlled directly by each system tested.

E) Attitude & Stabilization - attachment points to the Space Station must be provided unless seperate provision is made.

F) Viewing - No requirements.

G) Environmental Constraints - Structural test areas must be kept accessible.

H) Data Management, Communications - Data management requirements are minimal and well within baseline space station system designs.

I) Crew Timeline - Crew time requirements are a direct function of the priority assigned and the number of experiments conducted. Individual experiment results are not a direct function of crew interaction levels.

J) Operations, Schedule, Maintenance, Lifetime - TBD

VI. Space Station VS. Free Flyer

These experiments require significant human involvement in assembly, in order to provide for direct information feedback, on-site procedure revision and improvement. The structural systems technologies developed are directly applicable to free flyers but maximum return from initial experiments requires the direct interaction available on a Space Station.

Dale Stalnaker
Lewis Research Center

ZERO-GRAVITY BROMINE PHASE SEPARATION EXPERIMENT

I. Mission Objective

To study and demonstrate the homogenization and phase separation of polybromide complex and hydrogen gas from an aqueous bromide solution in a weightless environment. The information will be useful for designing zinc bromine flow batteries and hydrogen bromine fuel cells for space applications.

II. Mission Description

Hydrobromic acid, polybromide complex, and hydrogen gas are mixed into a single homogenous stream and circulated through test cells to simulate flow-by and flow-through electrodes. Various mixing conditions will also be simulated. The two liquid phases and the gas phase are then separated into three distinct phases by a centrifuge. The liquids are recycled to be mixed again. The size and quantity of gas and polybromide particles in the electrolyte are to be monitored at the inlets and outlets of the mixers and the centrifuge.

III. Benefit

Zinc-bromine flow batteries and hydrogen-bromine fuel cells are possible candidates for energy storage in space applications. The bromine produced by the charge reaction reacts with an organic complexing agent and forms polybromide, which is more dense and viscous than the electrolyte. In terrestrial systems this heavier phase sinks to the sump of the electrolyte reservoir. This separation increases the charge retention time. Hydrogen from the anode side can also transfer to the cathode and form a third phase. Data from multi-phase flow and separation experiments in zero gravity will be useful for designing high efficiency zinc bromine flow batteries and hydrogen bromine fuel cells for space applications.

IV. Justification

The zero-gravity effects to be observed in the Bromine Phase Separation Experiment can only be simulated in a weightless environment aboard the Space Station.

V. Mission Requirement and Capabilities

A.) Operational Envelope

1. Mass : 200-300 lb

2. Volume : under 5 ft^3

3. Pressure : 1 atm, requires N_2 source for 1 atm pressure

B.) Power : 500-1000 watts

C.) Thermal control: Thermostat control system is needed for a uniform temperature throughout apparatus.

D.) Operations Schedule

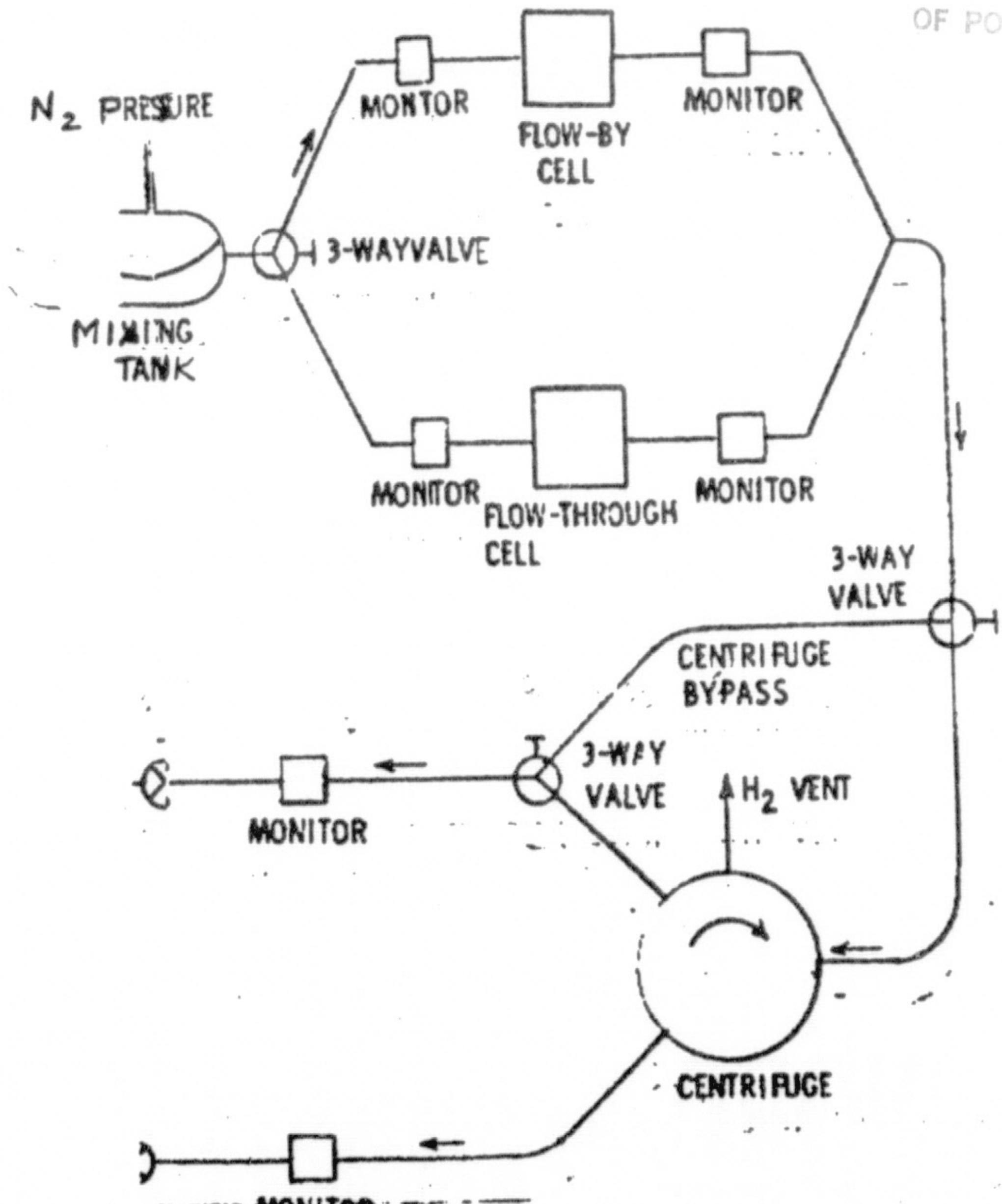
1. Mixing conditions will be varied by changing the flow rate and by passing the fluids through mixers or by-passing them.

2. No maintenance planned.

E.) Data Management and Communications

Polybromide droplets and hydrogen bubbles are monitored by particle counters for size distribution. Data may be recorded on tape or transmitted to the ground.

MIXING AND SEPARATION EXPERIMENT



Space Station

Contractor Cost Orientation
Briefing

NASA Space Station Task Force

September 15,1982

NASA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

SPACE STATION CONTRACTOR COST ORIENTATION BRIEFING

NASA SPACE STATION OFFICE

15 SEPTEMBER 1982

MAS COST ORIENTATION

GENERAL COMMENTS

- 0 IT IS NOT THE INTENT OF NASA THAT DETAILED COSTS RESULT FROM THESE STUDIES
- 0 THE USE OF REPORTING FORMATS AT THIS EARLY STAGE SIMPLY
    - 0 PROVIDES SOME FORMALITY
    - 0 WILL MAKE POST-CONTRACT EVALUATION EASIER FOR NASA
    - 0 WILL INFORM CONTRACTORS OF THE DATA REQUIREMENTS OF LATER STUDIES
- 0 THE WBS PROVIDED WAS DEVELOPED BY THE DOD/NASA/INDUSTRY SPACE SYSTEMS COST ANALYSIS GROUP (SSCAG)
- 0 ALL MAS CONTRACTORS HAVE REPRESENTATION IN SSCAG
- 0 BOTH THE WBS AND THE COST SPECIFICATION PROVIDED WILL BE BASELINED ON FOLLOW-ON CONTRACTS (THROUGH PHASE B OR EQUIVALENT)

COST ESTIMATING

AS PART OF THE COMPETITIVE PROCESS FOR SUBSEQUENT PROGRAM PHASES, CONTRACTORS MUST DEMONSTRATE:

- FAMILIARITY WITH NASA/DOD SPACECRAFT COST ESTIMATING STANDARDS
- ABILITY TO ESTIMATE PROGRAM COSTS, FOR ALL PHASES, WITH STATE-OF-THE-ART METHODS
- ABILITY TO TRADE COST AND PERFORMANCE AS PART OF THE SYSTEM DEFINITION AND DESIGN PROCESS
- ABILITY TO EXPRESS COST IN TERMS OF RISK/UNCERTAINTY

COST/SCHEDULE REPORTING

REPORTING REQUIREMENTS

- ALL CONTRACTORS MUST UTILIZE COST/SCHEDULE REPORTING SYSTEM VALIDATED BY DOD OR NASA.
- IT IS THE STATED INTENTION OF NASA TO UTILIZE EXISTING CONTRACTOR REPORTING SYSTEM WHERE POSSIBLE
- CONTRACTORS MUST SATISFY THE INTENT OF DRD MF003M, NHB7121.2, NHB9501.2 FOR COST ESTIMATING AND REPORTING
- REPORTING FORMATS WILL BE INDIVIDUALLY NEGOTIATED WITH OBJECTIVE OF LOWEST COST REPORTING SYSTEM

REVIEW OF PROCESSES

- AS PART OF THE COMPETITION FOR THE SUBSEQUENT PROGRAM PHASES, NASA WILL REVIEW COST ESTIMATING, REPORTING, AND COST/DESIGN TRADE SYSTEMS.

MAS COST ORIENTATION

GROUNDRULES AND ASSUMPTIONS

0 FY84 $ IN MILLIONS

0 COST SUBMITTED AT THE SUBSYSTEM LEVEL (E.G., AVIONICS, SYSTEM ENGINEERING) IF IT IS ESTIMATED AT THE LEVEL; OTHERWISE, ONLY TO LEVEL ESTIMATED.

0 SCHEDULES SUBMITTED AT THE MODULE LEVEL (E.G., HABITATION MODULE), WITH MAJOR SUBSYSTEM MILESTONES PRESENTED

0 MILESTONES SUBMITTED IN TERMS OF FY1, FY2 (INSTEAD OF 1985, 1986)

0 DRD MF003M FORMATS AND SSCAG STANDARD WBS SUGGESTED

NAME OF SSCAG MEMBERS
MAS CONTRACTORS

COMPANY	SSCAG MEMBER	PHONE
LMSC	KEITH BURBRIDGE	(408) 742-1123
TRW	JIM DRYDEN	(213) 535-2370
GAC	JIM WILDER	(516) 575-1873
RI	LEE TAUBE	(213) 922-4081
	STEVE KORNISH	(213) 594-3876
BOEING	STEVE OTROSA	(206) 773-1150
MARTIN	MAURY WILBUR	(303) 977-3931
GD	BOB BRADLEY (SD)	(714) 277-8900 X2513
	CLYDE PERRY (CORPORATE)	(314) 889-8605
MDAC	BILL HAGAN (EAST)	(314) 233-2611
	AL GOODWIN (WEST)	(714) 896-4866

SUGGESTED DATA FORMATS*

(SEE EXAMPLES ATTACHED)

DATA FORM	COLUMNS	CONTENT
A	1-6	- DDT&E, PRODUCTION, OPS BY WBS TO LEVEL 4/5 **
C	ALL	- TECHNICAL INPUT DATA TO COST ESTIMATING PROCESS
D	ALL	- TIME-PHASED COST ESTIMATES TO WBS LEVEL USED IN "A"
E	ALL	- ASSUMPTIONS MADE BY CONTRACTOR OF NASA SUPPORT REQUIREMENTS
H	ALL	- SUMMARY OF HARDWARE QUANTITIES USED IN ESTIMATING
I	N/A	- MAJOR MILESTONES USED IN ANNUAL COST PREDICTION, TO SUBSYSTEM LEVEL, IF AVAILABLE.

* CONTRACTORS SHOULD SUBMIT SEPARATE FORMATS FOR EACH PROGRAM OPTION RECOMMENDED TO NASA

** OR TO WHATEVER LEVEL USED BY THE CONTRACTOR, WHICHEVER IS HIGHER

DATA FORM A

DATE ____

PAGE ___ OF ___

NON-RECURRING (DDT&E)
RECURRING (PRODUCTION) X
RECURRING (OPERATIONS)

REF. LAUNCH DATE ____

FY84 $ IN MILLIONS

WBS NUMBER (a)	WBS NOMENCLATURE (b)	WBS LEVEL (c)	NO. UNITS (d)	REF. UNIT (e)	SELECTED COST (f)	HIGHEST COST (g)	LOWEST COST (h)	LEAD TIME (i)	COST DURATION (j)	SPREAD FUNCTION (k)	LEARNING INDEX (l)
1.0	HABITATION MODULE	3	2	1 + 2	500						
1.1	ECS	4	4	1 - 4	60						
1.2	POWER	4	1	1	25						
1.3	STRUCTURE	4	2	2	50						
1.X											

NOTE: WBS MUST BE CONSISTENT WITH THE SSCAG STANDARD WBS

EXAMPLE ONLY

ORIGINAL PAGE IS OF POOR QUALITY

DATA FORM C COST ESTIMATING METHODOLOGY & TECHNICAL CHARACTERISTICS

FY84 $ IN MILLIONS

a. WBS IDENTIFICATION NUMBER		b. COST EST	c. TYPE EST	d. HISTORICAL DATA USED	e. COMPLEXITY FACTOR	f. QUANTITY OR VALUE	g. KEY TECHNICAL CHARACTERISTIC	h. REMARKS
1. NUMBER	2. NOMENCLATURE							
1.0	HABITATION MODULE		*					
1.1	ECS	140	P	PROJECT OMEGA	1.4	100	# CRW, MSN LENGTH	DDT&E ESTIMATE
		60	P	"	1.0	60	# CRW, MSN LENGTH	PRODUCTION ESTIMATE
1.2	POWER	150	V		1.5	100		50% GROWTH ADDED TO VENDOR ESTIMATE FOR UNCERTAINTY DDT&E ESTIMATE
1.X								

* ENTRY CODE
V=BASED ON VENDOR QUOTE
P=PARAMETRIC ESTIMATE
D=DIRECT ESTIMATE OF MANPOWER
N-NASA-SUPPLIE

EXAMPLE ONLY

DATA FORM D

TOTAL PROGRAM FUNDING SCHEDULES

NON - RECURRING (DT&E) ☒

RECURRING (PRODUCTION) ☐

RECURRING (OPERATIONS) ☐

DATE ______

PAGE ____ OF ____

WBS IDENTIFICATION		TOTAL COST AT COMPLETION	FISCAL YEAR						
NUMBER	NOMENCLATURE		19 FY1	19 FY2	19 FY3	19 FY4	19 FY5	19 FY6	19 FY7
1.0	HABITATION MODULE	1500	75	150	250	500	250	150	75
1.1	ECS	140	14	28	56	28	14	0	0
1.2	POWER	150	15	30	60	30	15		
1.3	STRUCTURE	100	10	20	40	20	10		
1.10	MAJOR TEST					2 20	50	20	
1.X									
TOTAL DDT&E									
TOTAL PRODUCTION									
TOTAL OPERATIONS									
GRAND TOTAL LIFE CYCLE COSTS			EXAMPLE ONLY						

DATA FORM E

SUMMARY OF NASA SUPPORT REQUIREMENTS

a. WBS IDENTIFICATION		b. TYPE OF SUPPORT	c. UNITS OF MEASUREMENT	d. INCLUDED IN COST ESTIMATE		e. REMARKS
NUMBER	NOMENCLATURE			YES	NO	
1.0	HABITATION MODULE					
1.1	ECS	INTEGRATION	4000 HRS	X		CONTRACTOR WILL LEASE TEST FACILITY AT JSC
1.2	POWER	MAJOR TEST	400 HRS		X	ASSUMPTION THAT NASA WILL PERFORM MAJOR ELECTRICAL TEST AS AN IN-LINE ACTIVITY
1.3	STRUCTURE	TEST	400 HRS		X	ASSUMPTION THAT NASA WILL PERFORM MAJOR STRUCTURAL TEST

EXAMPLE ONLY

DATA FORM H
SUMMARY OF HARDWARE QUANTITIES

a. SUBSYSTEM	b. NO OF DEVELOPMENT UNITS	c. NO OF QUAL UNITS	d. NO OF MAJOR TEST UNITS	e. REFUR-BISHMENT UNITS	f. NO OF PRODUCTION UNITS	g. INITIAL SPARES	h. OPERATIONAL SPATES	i. TOTAL UNITS
1.0 HABITATION MODULE								
1.1 ECS	2	2	1*	0.5*	3.5*	0.6	2	11.15
1.2 POWER	2	1.5	1**	0.25**	0.75**	0.15	0.5	6.15
1.3 STRUCTURE								
1.X								

* 3 UNIQUE PRODUCTION ARTICLES + 50% REFURBISHMENT OF MAJOR TEST UNIT

** 75% REFURBISHMENT OF MAJOR TEST ARTICLE WILL YIELD PRODUCTION ARTICLE

EXAMPLE ONLY

DATA FORM I

MASTER SCHEDULE

* STRUCTURES SUBSYSTEMS

SUBSYSTEM OR MAJOR ASSEMBLY	CY 19				CY 19				CY 19				CY 19				CY 19			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
HABITATION MODULE o STRUCTURAL o SUBSYSTEM 1	ATP		PDR			CDR			MAJOR TEST			PRODUCTION TEST					DELIVERY			IOC
2														PRODUCTION						DELIVERY
ENERGY MODULE o STRUCTURE	ATP																			
TRANSPORTATION SUPPORT MODULE o STRUCTURES					ATP															
LOGISTICS MODULE																				
STRUCTURE 1																				
STRUCTURE 2																				
CONSTRUCTION MODULE																				

NASA-JSC

EXAMPLE ONLY

* MAY BE SUBMITTED AT MODULE LEVEL